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Decorative Treatment of a Bridge over a Chicago Boulevard

The track elevation work in Chicago includes the raising of two groups of railway lines which intersect each other at Ogden Ave. (just south of 12th St.), necessitating the construction of a long subway carrying nearly 20 tracks over this thoroughfare. This part of Ogden Ave. is one of the so called boulevards connecting the park system of the city, and is under the management of the West Park Commission. Although this is not an attractive part of the city, it was desired to have the boulevard crossing a somewhat more elaborate and artistic structure than the ordinary series of plain girder or trough-floor spans on rows of steel columns. A steel structure was decided upon by the railways, and the plan for improving its appearance was to apply a concrete casing to the deck and columns at each end, thus forming a somewhat ornamental portal. The finished work is shown in Fig. 1, and the details of this work are described later.

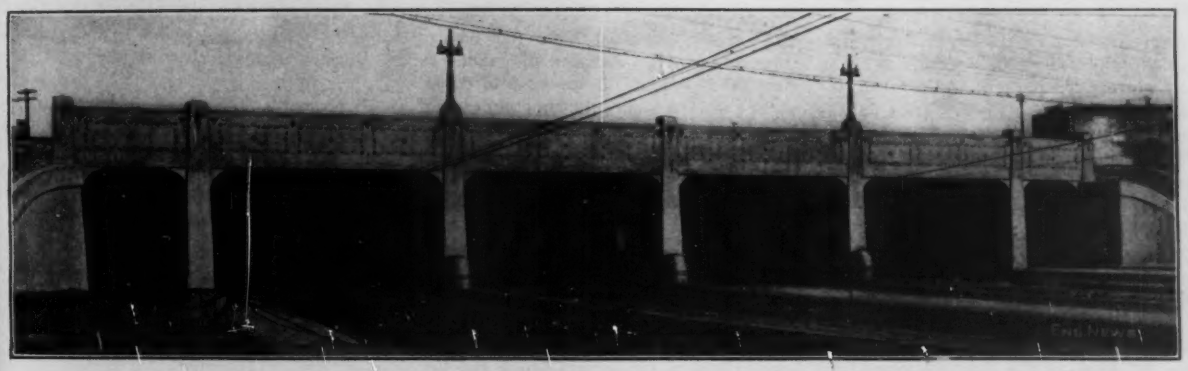

FIG. 1. CONCRETE PORTAL OF STEEL-GIRDER BRIDGE OVER OGDEN AVE., CHICAGO. (COLORED TILE DECORATION IN CONCRETE

GENERAL SITUATION

The avenue has a width of 122 ft. between curb lines, or 150 ft. over the sidewalks (between building lines). It has a 40-ft. central roadway for automobiles and pleasure traffic, separated by 15-ft. parkway strips from two side roadways of 26 ft. each. These latter roadways are for business traffic and each has one track of the street railway line. The street grade is depressed at the subway in order to limit the amount of elevation of the tracks. The width at the subway is 135 ft. between abutments and 109 ft. between sidewalks, the roadway being divided into four sections of 25 ft. clear width by the rows of columns supporting the track structure. Concrete guard walls inclose the bases of the columns, and from the ends of these there are concrete curbs carried to the parkways (which end at the subway approaches), so as to maintain the separation of the central and side roadways.

The tracks are owned by the Chicago & Northwestern Ry., the Pennsylvania Lines and the Baltimore & Ohio R.R. (Chicago Terminal R.R.). Some of them are curved, and those on the east section (B. & O.) are on a 10° curve, necessitating a curved face for the east side of the bridge. The western face of the bridge is straight. The total length of the subway is about 400 ft., but the arrangement of the tracks permits of leaving two open spaces, which greatly improve the light and ventilation, the bridge being thus formed in three separate parallel sections of different widths.

STRUCTURAL DESIGN

The general type of structure consists of five rows of columns with plate girders riveted between them and carrying self-supporting trough-floor spans. The details vary in the parts built by the different railways, but the following description relates to the eastern section of the bridge, built by the B. & O. R.R. This is shown in Fig. 2. The columns (four in each row) are of H-section; each is composed of two channels (with flanges outward), a web plate parallel with the line of the street, and four inside connecting angles; batten plates are riveted across the channel flanges on the open sides. Between the faces of the columns are riveted girders parallel with the street. As the width of bridge varies from 46 ft. at the north to 55 ft. at the south (owing to the curve), the lengths of the girders vary in each of the five rows; in the north row there is a 16-ft. central girder with two 15-ft. side girders, while in the south row they are 19 and 18 ft. long, respectively. These girders support a floor of rectangular steel troughs 19½ in. wide and 26 in. deep; these are at right angles to the girders, and a row of diaphragms is placed across the troughs at mid-span. The troughs are filled and covered with concrete, upon which is laid the ordinary ballasted track construction.

For the sidewalk spans, however, the floor is of I-beams, having the same 19½-in. spacing as the troughs; concrete is filled between and over these to form a solid deck. Along each side of the bridge is a 51-in. facia girder, having a ⅜-in. web and four flange angles 8x8 in. The type of construction is similar to that adopted for the subways on the track elevation work of this line.

CONCRETE CASING OF PORTALS

The plan adopted to give an attractive appearance to the structure, as noted above, was to mask the steel work of each

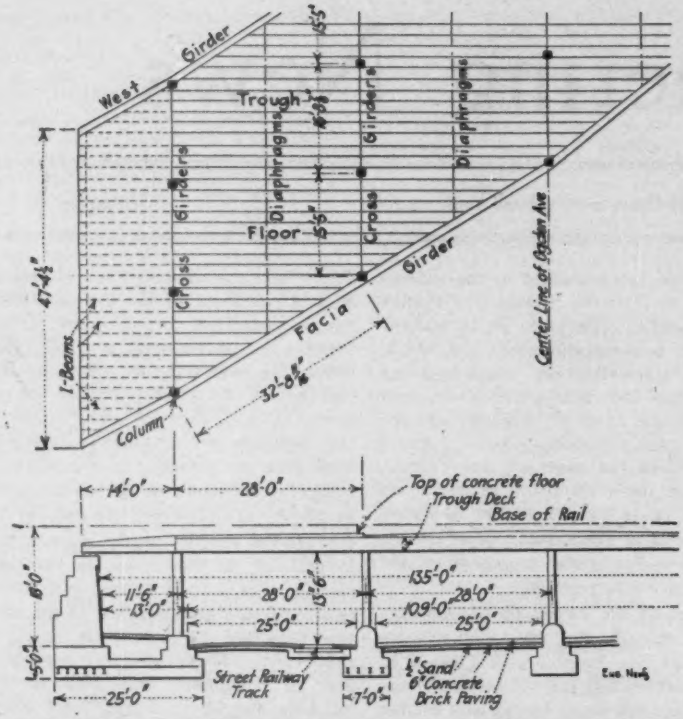

FIG. 2. PART PLAN AND ELEVATION OF THE OGDEN AVE. BRIDGE (B. & O. R.R. SECTION)

portal or street front with concrete, giving the appearance of concrete columns and girders, or parapet walls. The design for this was made by Price & McLanahan, architects, of Philadelphia, Penn.; the work at the west portal was done by the Pennsylvania Lines and that at the east portal by the Baltimore & Ohio R.R., the J. J. Croakes Co. having the contract. Fig. 1 is a view of the west portal; this is straight, while the other one is on a curve, as noted already.

The column and girder work of the B. & O. R.R. are shown in Figs. 1 and 3 (on the work of the Pennsylvania Lines the column channels have the flanges turned inward). The size of column is from 36 in. square at the base to 30 in. at the top. To secure the concrete casing, horizontal anchor bars are placed at the top, middle and bottom of the column, being attached by means of hook bolts passing through holes in the flanges of the channels. The ends of the anchors are hooked, so as to support four ¾-in. round rods. For the attachment and reinforcement of the concrete casing of the facia girders, vertical rods are placed about 3 ft. apart, with the lower end bent to rest on the bottom flange and the upper end held by a diagonal rod hooked to the top flange. Short horizontal transverse bars are hooked to the top of the girder and to holes in the web, and three lines of longitudinal bars complete the framework. To this is attached a netting of rectangular mesh in order to prevent cracks due to vibration. All the bars are ¾-in. round rods. Rivets in the girder flanges were knocked out at places where the bars had to be attached. The thickness of the concrete is 12 in. for the parapet wall and 10 in. against the face of the girder.

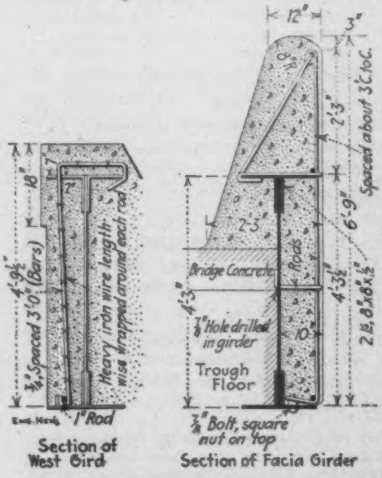

FIG. 3. SECTIONS OF CONCRETE-CASED FACIA GIRDERS

The four girders of the two intermediate openings in the subway roof are encased in concrete, but without decorative treatment. The reinforcement consists of ¾-in. vertical bars 3 ft. apart, hooked over the top flange, and hooked at the bottom to carry a 1-in. rod. Between the vertical rods are horizontal lines of heavy wire, wrapped or tied to the rods. This construction is shown at the left in Fig. 3 which is the west girder of the B. & O. R.R. section of the bridge.

The concrete is a 1:4 mixture, using crushed limestone ranging in size from dust to ¼-in. The concrete mixer was placed on the ground, and its engine operated a hoist for raising the barrows or buckets to the top of the bridge, where they were wheeled to the desired point for dumping. The forms were of wood, carefully surfaced, any small cracks or crevices being filled with plaster of paris. The concrete of the columns was poured first, and when this had set it formed a support for the forms for the girder work. On the curved side, it was necessary to use falsework to support these girder forms.

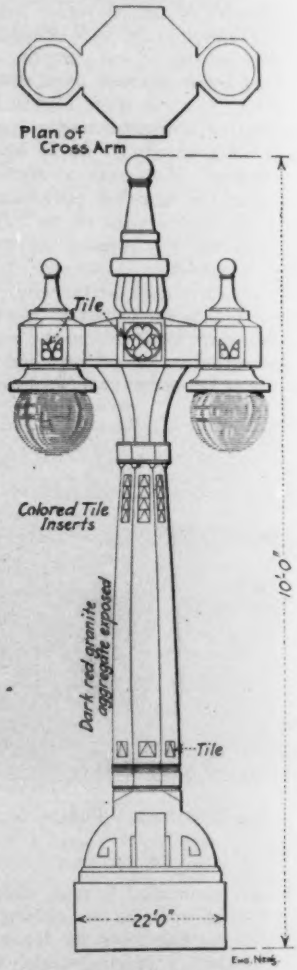

FIG. 4. CONCRETE LAMP POST FOR TRACK ELEVATION, BRIDGE OVER OGDEN AVE., CHICAGO

DECORATIVE TREATMENT

The novel feature of the work is the decoration of the concrete by means of colored tile (as may be seen in Fig. 1) in order to relieve the appearance of the

flat surfaces of concrete. There are no panels, copings or moldings to break the surfaces, although the girders are set back slightly from the faces of the columns. The only other feature in point of shape is the use of small curved brackets to relieve the sharp corners of the rectangular openings. The face of the forms had wooden blocks nailed in place to form recesses for the tiles, these blocks being somewhat larger than the tile. After the forms had been removed the tiles were placed, being set in portland cement mortar and not anchored in any other way. Finally the concrete was given a brush coat of portland cement grout.

Curved wing-walls slope from the top of the abutment to the retaining walls along the sidewalks at the approaches. Each portal has four ornamental lamp posts of concrete, two on the bridge and two on the ends of the wing walls (the latter not appearing in Fig. 1). The design of the posts is shown in Fig. 4. The facing concrete of these is made with coarse, red granite, and this is given a rough granular surface by means of a wash of diluted muriatic acid followed by scrubbing with wire brushes. This removes the surface skin of cement and leaves the aggregate exposed. This method of treatment has been employed extensively for buildings, lamp posts and decorative work in the Chicago parks, various shades and colors of stone in the aggregate being used to give the desired effect.

The general idea of the concrete portals is good, and the design is pleasing when viewed from a distance, but it must be said that in detail the results are far from satisfactory and do not bear close inspection. The smooth skin of cement on the girders is covered with craze cracks, and is blotched and discolored, while the uneven patching of cement mortar around the tiles is unsightly, being of a different color from the concrete. The tile color scheme is not pleasant, consisting largely of a crude yellow which does not harmonize with the color of the concrete. And in several cases the face of the tile seems to have scaled off. Probably a better appearance would have resulted if a rough or sandy granular surfaoe had been given to the face of the concrete (as in good sidewalk work) instead of the smooth cement skin surface. Another feature which detracts from the appearance is the rough and bare condition of the slopes of the railway banks at the approaches. To harmonize with an ornamental bridge of this character the slopes certainly should be graded and covered with grass, if this is in any way possible.

Some aspects of the general questions which have frequently arisen in providing artistic bridges over city streets, are discussed in the editorial columns of this issue.

Rail Anchor or Anti-Creeping Device on the C. B. & Q. R.R.

The use of rail anchors or anti-creepers to prevent the longitudinal movement of rails upon the ties has become very general within the past few years, since the creeping has increased to a very marked degree under conditions of increase in wheel loads and traffic without a proportionate strengthening of the track structure. This subject was dealt with in our issue of June 27. The two principal types of creepers are (1) those which are bolted to the rail web and spiked to the tie, and (2) those which are fastened to the rail flange and bear against the side of the tie.

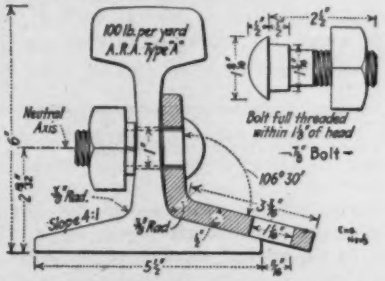

FIG. 1. CROSS-SECTION OF RAIL ANCHOR OR ANTI-CREEPER; CHICAGO, BURLINGTON & QUINCY R.R. T. E. CALVERT, CHIEF ENGINEER

The Chicago, Burlington & Quincy R.R. has for years used very extensively an anchor of the former type, consisting of a pair of short pieces of angle bar, bolted to the middle of each rail and spiked to the tie through a slot in the flange of the anchor. This is quite satisfactory so far as its anchoring capacity is concerned. But as it holds only one

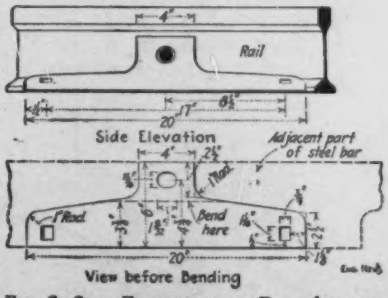

FIG. 2. SIDE ELEVATION OF RAIL ANCHOR (The dotted lines show the way in which it is cut from a bar without waste.)

tie, the other tie under the joint opposite the anchor (the tails being laid with broken joints) is apt to skew and cause trouble. None of the clamp anti-creepers of the second class used on this road have proved satisfactory, failing in various ways.

To avoid this trouble of ties skewing with the anchors first mentioned, a new form of anchor of the same class was designed, having the flange long enough to cover the two ties. The construction is shown in Figs. 1 and 2, and it will be seen that only one bar is used instead of a pair of bars; this is placed on the inner side of the rail. There are two spikes (one to each tie) and these are driven in holes instead of slots, thus holding the creeper more securely. The drawing shows a spring washer under the nut, but we are informed that these are not now used as they were found to crack and leave the bolt loose. The anchors are made in a very simple and economical manner, being cut from strips of ½-in. boiler plate in such a way that there is no waste. This is shown by Fig. 2. The pieces thus cut to shape are bent in a former to the required angle.

This device is the invention of T. E. Calvert, Chief Engineer, C., B. & Q. R.R., to whom we are indebted for information regarding it. It has been in use about a year, and has proved quite satisfactory. About 1000 are now applied.

The Valuation of Public Utilities—Few engineers are so thin-skinned that they cannot enjoy a joke on themselves. We think the following story by Henry J. Davies, Secretary of the Cleveland Railway Co., in the July issue of the "Journal" of the Cleveland Engineering Society, will be enjoyed by all members of the profession:

My principal experience with expert engineers as counsel and witnesses was in connection with the appraisal of the street railway properties here [in Cleveland] in 1907, 1908 and 1909. We examined our own engineers and others as to the extent of the physical property and the cost of construction. We also called expert engineers of the widest reputation to testify not only as to the value of the property that appeared on the ground, but as to how much should be added to that value for what they termed "overhead charges," including contingencies, things that could not be seen on the surface, such as organization, engineering, legal expenses, interest during construction, consents of lot owners, brokerage, financing—perhaps 20 other items. With their wonderful imaginations, they saw many things that we had not seen. And they proved their dreams. By most convincing arguments, they showed that the things they saw in imagination were real. Among the engineers that we called were William Barclay Parsons, Bion J. Arnold and Prof. Mortimer E. Cooley, of the University of Michigan. I remember a story that Thomas Bailey Aldrich once told of his boyhood. Among his playmates was one who was always their leader, or who was always successful in their games, who won their marbles, whose kite flew highest, whose sled coasted fastest. They agreed one summer day that the next morning their would fly their kites, and would name them all. One of the boys named his "Morning Star." Aldrich named his "Excelsior." But the boy who was the winner, always, had spread all over his kite, "Nearer, My God, to Thee." Arnold was our bright Morning Star; Barclay Parsons was Excelsior; but Prof. Cooley came nearer, my God, to Thee, in the matter of overhead charges, than any of the others. But Prof. Cooley and the others backed up their statements with very cogent arguments. Prof. Cooley had such confidence in his own testimony and in his profession that he said that he believed his estimates were under-estimates, the art of valuing second-hand railroad properties being still in its infancy. The engineers added varying percentages, saying that their experience indicated that in most works as large as a city street railroad the actual cost usually largely exceeded the engineers' estimates.

New Sewer Work at St. Louis, Mo.

By W. W. Horner*

Of the large amount of sewer work now under way in St. Louis, much is of interest on account of the size of the sewers and the magnitude of the work. Two of the smaller contracts recently finished, however, involve peculiar features which seem worthy of special notice. These are the Dale Ave. Joint Sewer and the concrete girder sewer in Glaise Creek, District No. 3, both of which are described in this article.

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The Dale Ave. valley is one of the subareas of the River des Pères in the southwestern part of the city of St. Louis. It contains about 300 acres, of which 60 acres, at the upper drainage area, are outside the city limits. The valley may almost be called a ravine, as it is so narrow and the sides are so steep that any considerable deviation from the line of the water course encounters high ground. For this reason, the economical location for the sewer was restricted to one general line.

As may be seen from Fig. 1, only one public street follows the direction of the valley, Dale Ave., formerly the Valley Road. The name Valley Road is, however, a misnomer. This street leaves Manchester Ave.—the main thoroughfare of this portion of the River des Pères valley—on high ground and descends along the side hill to the bottom of the ravine in a distance of about a thousand feet. To the west of this portion of Dale Ave. the valley is quarry property, with the creek skirting one edge of the quarry. Farther up the valley, Dale Ave. follows the creek for another thousand feet. In the next thousand feet the "dale" is given up to clay mines, while Dale Ave. crosses a ridge 30 ft. above the water course. Above this point, the valley is subdivided and built up, but most of the streets, at the time that the sewer was designed, were "private," that is, had not been dedicated to public use.

In the original location of the sewer, the line passed through the culvert which carries the Dale creek under Manchester Ave. and crossed the quarry property. It then followed the low stretch of Dale Ave., crossed over the clay mines and through various rights of way to the city limits. This line was all in low ground and the average cut would not have been much over 10 ft.

At first no great difficulty was expected in obtaining the rights-of-way, but when the approximate estimate of cost had been made and the amount of the tax bills estimated, the large owners began to reconsider the proposition. A great deal of discussion followed. The small owners in the upper valley were very active in assisting in securing the rights-of-way, and a continuous line through that portion was finally obtained—a very devious line, but a fairly economical one.

In the meantime, the holders of the large tracts in the lower valley had been giving the right-of-way question serious consideration, first favorable, and then hesitant with much futile discussion. When these two rights-of-way were finally refused, the large majority of the residents objected to further delay for condemnation proceedings and insisted that the sewer be built at once, if not all in low ground, then if necessary, in high. The conditions of sanitation had, in fact, become such that further delay would have been dangerous and plans, locating the sewer in Dale Ave., were prepared. This bit of history has been given to explain the origin of the conditions which made necessary the peculiar design hereinafter described.

The line finally used is 6000 ft. long

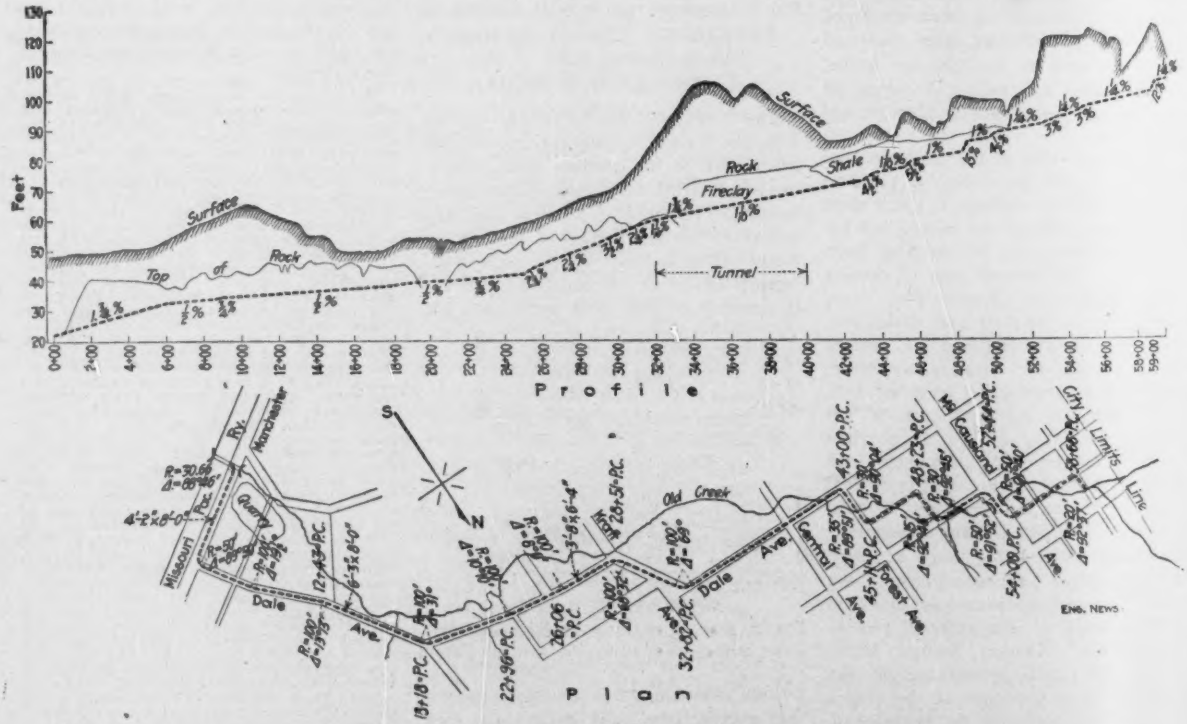

FIG. 1. PLAN AND PROFILE OF DALE AVE. SEWER, ST. LOUIS, MO.

and contains 16 curves, one of which is of only 15 ft. radius. The lower end of the sewer is at the old culvert in Manchester Ave. and the line from there follows Manchester Ave. and Dale Ave. to Forest Ave.; west of Forest Ave. the line is in rights-of-way except the short piece in McCausland Ave. A condensed plan and profile is shown on Fig. 1.

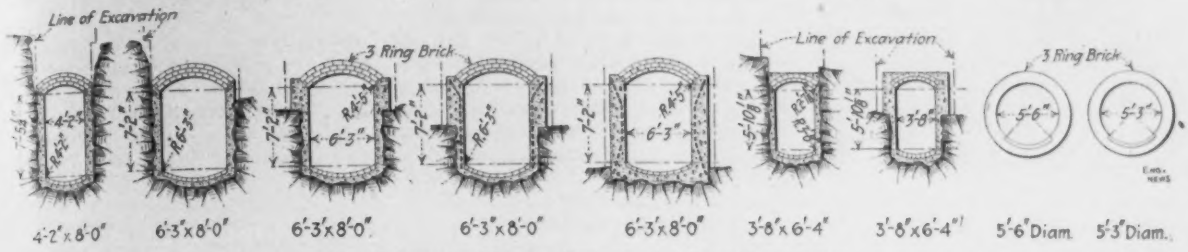

FIG. 2. DETAILS OF VARIOUS SECTIONS OF DALE AVE. SEWER

BORINGS

Punch borings were taken at intervals of 50 ft. along the line and additional holes were put down where abrupt changes in the rock surface were found. This work was done by a gang of four men, using ⅞-in. steel rods. These rods are in 12 ft. length, with special sleeves. The boring point which screws to the lower end is about a foot long and tapers from a shoulder somewhat larger than the rod to a fine point. Another point called the "punching rod" is practically a churn drill and is used to punch through boulder or ledge. Levels are taken at the top of each hole, and measurements by an inspector give the elevation of each sample and of the surface of the rock. In boring, two men usually ride the handle bar while two others turn the rod. In hard ground, a small amount of water is used to soften the clay and lubricate the hole. The boring is done in 5-ft. stages, at the end of each of which the rods are removed and the point replaced by the spoon, after which the rods are again put down and a sample taken in the spoon. In soft ground these samples are not of great value, as the hole may close in and the spoon become partially filled before reaching the bottom of the hole. In firm material, however, if proper care is used, a true sample may be obtained. When rock is struck, the punching rod is used and old hands can tell by the ring when the rod is dropped whether the rock is strata of hardpan or obstructions which may be encountered.

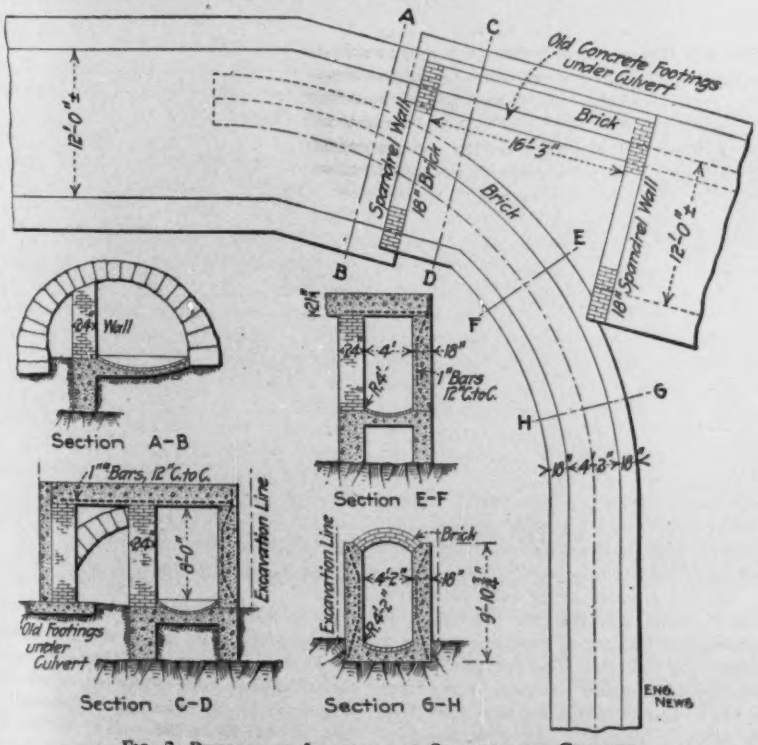

FIG. 3. DETAILS OF JUNCTION OF SEWER WITH CULVERT

Rock was found from Sta. 0 to Sta. 25 as noted in Fig. 1. At about Sta. 25, the rock ran out and was replaced by hard shale and fire clay. Boring in these materials was very difficult and tedious, and it was often impossible to put the hole to the required depth. Near the proposed flow line also a hard gray substance was encountered. This was rather gritty, but it was impossible to tell, from samples, whether it was a sandstone or shale. The deep holes between Sta. 35 and 45 gave a great deal of trouble. It was difficult to put down the holes and more so to get the rods out. A tripod, with blocks and tackle, had to be used in removing the rods. An ordinary earth auger was tried and broken off sharp, while a helical auger, of ½-in. wrought iron, simply untwisted. Four of the holes finally reached grade, and the findings were so far uniform that the remainder were abandoned. It was found that this portion of the sewer would be in fire clay, similar to that being mined on the east side of Dale Ave., overlaid in places by rock. From Sta. 45 to the end, the material was found to be fire clay and shale, overlaid with a varying depth of yellow clay. These borings agreed well with the known sub-grade conditions of the valley, as both fire clay and coal had been mined there.

Owing to the nature of the material encountered, the cost of the boring work was much higher than usual. The data follow:

Number of holes bored	116
Total depth	1,435 ft.

Of this depth, about 300 ft. were through hard shale and 40 ft. were through old macadam road; of the remainder, about half was through very hard clay and gravel.

Average depth of hole	13 ft.
Minimum depth	2 "
Maximum depth	30 "

The work was done in 20 days, during a part of which time four gangs were used. The total labor amounted to 180 days, or 45 days' work for a gang of four men. This gives an average depth bored of 32 ft. per gang per day, which amounts to 25c. per lin.ft. of boring. Such work through ordinary clay and loam costs from 6 to 10c. per ft. for holes averaging 15 ft. deep and spaced from 50 to 200 ft. apart.

TABLE I—DATA FOR COMPUTING TOTAL CURFE COMPENSATION

Location	Length lc.	Radius	Compensation 47.6 / r2	Total Compensation lcx47.6 / r2
Sta. 50.....	32	20	0.12	3.84
" 54.....	80	50	0.02	1.60
" 52.....	80	50	0.02	1.60
" 50.....	49	30	0.05	2.45
" 48.....	24	15	0.20	4.80
" 45.....	47	30	0.05	2.35
" 43.....	55	35	0.04	2.20
			Total....	18.24

The next determining point was at Forest Ave. (Sta. 43). A ½% grade eastward from this point, with a steep descent at Sta. 30, would still have left the maximum cut at Sta. 35 about 38 ft. As it would have been very uneconomical to open so deep a trench in fire clay and shale, a straight grade was used and provision was made to tunnel this section (Sta. 32 to 40). The remainder of the grade in the upper valley was set to suit the elevations of proposed tributaries. These grades were, of course, only preliminary and were modified as described below, to allow for curve compensation and for final close adjustment with proposed laterals.

TABLE II

Computation Table for Dale Ave. Joint Sewer.

APPROXIMATE length of creek from upper end to Sta. 59+82 of Sewer = 2400 ft.
APPROXIMATE average velocity of creek 4 ft. per sec.
Allowing 5 min. as time of flow to Creek at the upper end of the water shed, time concentration at Sta. 59+82=2400÷4×60+5=15 minutes.

Sta. to	Station	Drainage Area	pI	Required Q Capacity	Actual Capacity	S %	V	Length	Time of flow t	Critical time T	Size
59 + 82.00	50 + 06.93	76.43	2.20	168.15	174.0	1.25	13.9	975.07	1.2	15.0	40x60 in.
50 + 06.93	45 + 58.28	130.15	2.13	277.22	276.0	1.0	12.8	448.65	0.6	16.2	63 in.
45 + 58.28	31 + 50.00	149.10	2.10	313.11	325.5	1.1	13.7	1408.28	1.7	16.8	5½ ft.
31 + 50.00	29 + 93.75	227.38	2.03	461.58	462.0	2.25	19.3	156.25	0.6	18.5	5½ ft.
29 + 93.75	25 + 00.00				466.1		20.6	493.75			3 ft. 8 in.x6 ft. 4 in.
25 + 00.00	5 + 19.63	322.86	2.02	652.18	661.0	0.50	13.7	1980.37	2.4	19.1	6 ft. 3 in.x8 ft.
5 + 19.63	0 + 00.00	322.86	2.02	652.18	655.8	1.75	20.1	519.63	0.4	19.1	4 ft. 2 in.x8 ft.
								5982.00			

TABEL III.

Station Elevations After Grade Compensation.

Station	Distance ft.	Grade %	Fall ft.	Elevation ft.
0 — 02.50				21.95
5 + 19.63	522.13	1.75	9.14	31.09
5 + 98.00	78.37	1.75	1.37	32.46
8 + 59.06	261.06	.50	1.31	33.77
8 + 93.03	33.97	.75	.25	34.02
12 + 43.52	350.49	.50	1.75	35.77
12 + 66.59	23.07	.50	.12	35.89
18 + 16.87	350.28	.50	2.75	38.64
18 + 70.89	54.02	.75	.41	39.05
25 + 00.00	629.11	.50	3.14	42.19
25 + 00.00			1.37	43.56
26 + 20.29	120.29	2.25	2.71	46.27
26 + 34.44	14.15	2.25	.32	46.59
28 + 82.86	248.42	2.25	5.59	52.18
29 + 93.75	110.89	3.50	3.88	56.06
31 + 50.00	156.25	2.25	3.52	59.58
32 + 82.44	132.44	1.10	1.46	61.04
33 + 72.77	90.33	1.75	1.58	62.62
41 + 00.00	727.23	1.10	8.00	70 62
42 + 99.38	199.38	1.10	2.19	72.81
43 + 54.27	54.89	4.50	2.47	75.28
45 + 11.12	156.85	1.10	1.73	77.01
45 + 58.28	57.16	5.50	2.59	79.60
48 + 23.76	265.48	1.00	2.65	82.25
48 + 47.96	24.20	15.00	3.63	85.88
49 + 58.37	110.41	1.00	1.10	86.98
50 + 06.93	48.56	4.50	2.19	89.17
52 + 45.27	238.34	1.25	2.98	92.15
53 + 26.01	80.74	3.00	2.40	94.57
54 + 03.16	77.15	1.25	.96	95.63
54 + 83.18	80.02	3.00	2.40	97.93
58 + 66.16	382.96	1.25	4.79	02.72
58 + 98.48	32.32	12.00	3.88	106.60
59 + 82.00	83.52	1.25	1.04	107.64
Total.....	5,984.50		85.69	
			21.95	
Check.....				107.64

GRADES

From Sta. 16 to 30, the sewer grade parallels the proposed grade of the street and is as near the surface as drainage conditions will allow. From Sta. 16 to the outlet, several combinations of grades were tried and estimates made on each. The straight grade gave a smaller average sewer size but a considerable depth of cut, the increase being entirely in rock. The flatter grades from Sta. 18 to 6, with steep grades from Sta. 6 to the outlet, were more economical, until the upper grade was made less than ½%, when the size of the sewer increased so rapidly that the total cost was again higher. The grades shown in Fig. 1 gave the cheapest line and was used.

FINAL GRADES AND COMPENSATION

The steep lateral slopes in this valley give a very rapid concentration of rainfall into the sewer, and the steep grades on the main sewer combined with the comparatively large runoff result in high velocities (see Table II). This made it very important that the design should provide for a smooth flow with no points of abnormal resistance, as a sudden checking of the velocity would create a pressure head which might do considerable damage to the property along Dale Ave.

These conditions are abnormal for St. Louis, where the average grade of the secondary sewers such as this is from ¼ to ¾%, and where the broad streets make it possible to construct curves of from 50 to 100 ft. radius. For this reason and because of the deep excavation required, the Dale Ave. project received more detailed study than much of the larger work and every effort was made to secure a construction that was both economical and entirely safe.

The old practice under such conditions would have involved the flattening of grades and the use of tumbling basins to check the velocity. The tumbling basin, however, introduces unknown factors into a sewer system which we now think best to avoid, if possible, and it is questionable whether the basin really acts to much advantage under extreme conditions. Such construction is very expensive, for if the sewer is deep enough above the basin, it is too deep below, involving excessive excavation; also, if it is supposed to check the velocity, much larger sewers are required for the flat grades. The present practice is to design the sewers carefully at all points and to take advantage of all the natural fall in order to decrease the size of sewers; then to build strong enough to take care of the resulting high velocities.

In this work the curves were compensated by the Markmann Formula, described by the writer in ENGINEERING NEWS, Sept. 29, 1910, p. 326. This formula is:

$$Sc = S + \frac{v^3}{2gr^2} \qquad (1)$$

Where Sc = grade or fall per foot on the curve, equivalent to a grade S on the tangent; v = velocity due to grade S; r = curve radius in feet, and g = acceleration of gravity. In applying the formula it is necessary that the velocity be known and this can only be obtained from the finished computations. This involves a system of trials, and in practice the compensation and consequent modification of the tangent grades is made a part of the general design records.

Beginning at the upper end of the sewer, the tributary area and the critical time are known. For the critical time, the runoff curve (see article above noted) gives the value of pI, the runoff per acres; this multiplied by the tributary area gives the runoff or the capacity of the sewer in cubic feet per sec. (ApI). As explained above, a preliminary grade, S has already been plotted. Suppose the section of sewer to which the computed runoff applies to consist of a tangent of length l, and one curve length lc; the actual grades then will be S and Sc and the total drop in grade =

$$Sc\ lc + S\ l \qquad (2)$$

This formula is of no direct value in the computations, but a grade S may be assumed somewhat less than the preliminary grade and from this and the required capacity the velocity is quickly determined from Fig. 7 or Fig. 8 of the article above noted. (ENGINEERING NEWS, Sept. 29, 1910, p. 329). Substituting the values of v and S, in the Markmann Formula (Eq. 1) a value of Sc is obtained, and the values of S and Sc may be checked by substitution in Eq. 2. A second trial will usually be sufficient for final computations.

The actual computations were as follows:

From the end (Sta. 59 + 82) to Sta. 43, the preliminary grade was 2%, a fall of 34 ft. First assume that the curve compensations will reduce the grade on tangent to 1½%. The time of concentration at Sta. 59 + 82 (see Table II) is 15 min., which makes pI for the rainfall and runoff curve (Fig. 6 of previous article noted) 2.20, and as the acreage tributary at that station is 76.4, the total runoff ApI, 168 cu.ft. per sec. Now, entering the graph of Kutter's formula (pub-

lished as Fig. 7 of previous articles noted) for a grade of $S = 0.015$, the nearest standard capacity to 168 cu.ft. is 174 (see Table II); follow vertically to the curve marked "Q for $S = 0.015$," thence horizontally to the curve "v for $S = 0.015$" and vertically to the base line, where v is given as 14.5 per sec. Substituting in Eq. 1,

$$Sc = S + \frac{47.6}{r^3}$$

which applies, for a first trial, to all curves between Sta. 43 and 59.

Substituting the values of r for the different curves in this section, Table I was obtained.

FIG. 4. SMALL SECTION OF DALE AVE. SEWER UNDER CONSTRUCTION

This gave a fall of 18.84 ft. to be used in curve compensation. Subtracting this from the total fall 34 ft. leaves 15.16 ft. in 1682, or a grade of 0.9% instead of 1½% assumed above.

A repetition of this computation assuming a grade of 1¼% instead of 1½% gives $v = 13.9$; $\frac{v^2}{2g} = 42$; and the total compensation 16.6 ft. This leaves 17.4 ft. of fall in 1682 or a grade of 1.04%. In the final adjustment grades of 1¼, 1⅛ and 1% were used in this section which with compensations made the total fall 34.83 ft. as shown in Table III.

A peculiar feature of this method of computing runoff is illustrated in the following point: The last tributary of any size reaches the sewer at about Sta. 22, but to avoid another small change of section and to allow for possible realignment (no public streets now exist in this section), it was considered as entering at the break in grade at Sta. 25 Below this point, there are 2500 ft. of sewer into which no appreciable lateral drainage is taken. The conditions for maximum runoff through this whole 2500 ft. are therefore the same as those at Sta. 25 and the critical time is 19.1 min. In spite of the fact that the flood wave will not reach the outlet until 21.9 min. after the beginning of the downpour.

The computation table (Table II) was now started. The first large tributary comes at Sta. 50 + 06. The runoff from Sta. 59 + 82 to 50 + 06 is 168.15 cu.ft. per sec. Using the 1¼% grade, the graph (Fig. 7 of previous article) gives a 40x60-in. sewer with a velocity of 13.9 cu.ft. per sec. Substituting this velocity in the formula, the grades for the first three curves are gives as 12%, 3% and 3%. The station distance, grade fall and location of flow line are carried along in Table III. At this point, it was seen that the 1¼% grade would place the sewer a little lower than necessary, so a 1% grade was used for the next section.

The velocity of the first section was 13.9 ft. per sec. and the length 975.07 ft., so the time of flow would be 1.2 min. Adding this to the 15 min. time of concentration at the upper end gives 16.2 as the critical time at Sta. 50 + 06. From the rainfall runoff curve for 16.2 min., the runoff per acre (pI) is 2.13. The total acreage at Sta. 50 is 130.15, and the required capacity 277.22. From the graph, 277 ft. per sec. on a 1% grade, requires a 63-in. circular sewer, the velocity of which is 12.8 ft. per sec. The compensation in the next two curves was then computed and the elevations in Table III were brought up to date.

This process was repeated for the whole line, the tables being worked together. The grades and elevations were plotted on the profile as fast as computed and slight changes were made from time to time to keep the flow line near the elevations on the preliminary grade.

In this work, the rectangular sections were not considered but circular sewers were used instead, so that the diagram for Kutter's formula could be used. When the whole line had been computed, the rectangular sections were designed, but the velocities were so near those for the circular sewers first used that very little change of grade was necessary.

DESIGN OF SECTIONS

Sewers of the capacities required for this line are usually made of circular brick, but the deep rock cut in the lower portion would have made such a construction very expensive. As the heavy rock work which would be necessary in any case made this district more expensive than the average, every effort was made to reduce the cost as much as possible. It was evident that by making the sewer narrow and high, the amount of excavation would be materially decreased, even though the flow line had to be lowered to keep the top of the sewer at a normal depth through the low portion of Dale Ave. As the ratio of the height to the width $\left(\frac{h}{w}\right)$ increased, however, the section became less efficient from the hydraulic standpoint, requiring a greater wetted area for the same capacity. The problem for the design was to find the value of $\frac{h}{w}$ which would give the cheapest sewer for this section. Owing to the

number of conditions to be satisfied, it was impossible to work this out directly, but by trial it was found that the best ratio had a value of between 1½ and 2.

There was also an advantage in keeping the height of the various rectangular sections as nearly constant as possible, as this obviated the necessity of using upgrade to take up the difference in height, which had to be done at Sta. 25.

The rectangular sections, shown in Fig. 2, were designed for three conditions. In the first, the natural rock surface is at or above the skew back of the flat arch. In this case, the arch carries the whole load to the rock. The 9-in. concrete walls are intended to smooth up the sides, as is the concrete in the bottom. In the second case the rock is slightly below the skew back and 18-in. concrete work is used. In the third case, rock more than 3 ft. below the spring line, 18-in. concrete walls were used, reinforced by 1-in. steel bars on 12-in. centers. These side walls were designed as beams, carrying the arch thrust at the upper end and relieved by earth pressure below. Where no rock was encountered, the sides or beams were considered as supported at the bottom by the invert and at the top by the arch. As a matter of fact, the material above the rock was so hard that it will probably take the whole thrust of the arch direct and will itself exert little or no pressure on the side walls.

Junction Chamber

To avoid crossing the right-of-way of the Missouri Pacific Ry., the outlet of the sewer was made into the old culvert under Manchester Ave. (Fig. 3). The sewer turns into the culvert at an easy curve, which cuts through the side of the old stone arch for a length of about 16 ft. The old culvert was torn out for this length and a new chamber constructed. The old concrete footing on the west side was used. The design called for a 24-in. vertical brick wall on this side with brick spandrels over the ends of the old arch. The east side and a curving center wall are continuations of the walls of the sewer. The east, west, center and spandrel walls were brought up to an even elevation and the whole covered with a 21-in. reinforced-concrete slab.

Construction Work

Work was started in August, 1910, at the culvert chamber on Manchester Ave. This chamber was opened as a shaft 20x18 ft. All excavation was handled with a derrick. Following this, the Manchester Ave. section was started, a Potter machine being used from the culvert to a point part way around the curve. A small cableway, about 300 ft. span, was set up on Dale Ave. and a part of the curve was handled with this. This cable was used five times between Manchester Ave. and Buck Ave., handling all of the excavation except part of the two curves.

Work was also started at the lower end of the tunnel (Sta. 32) with a derrick, which moved back to about Sta. 29; at this point, another small cable was installed on Dale Ave. This cable was moved once. After completion of the tunnel, a cable was installed on Dale Ave. east of Forest Ave. These two machines alternated throughout the remainder of the line, the cable taking the east and west stretches and the derrick the shorter north and south pieces and the curves.

All excavation was done by pick and shovel and the excavated material was loaded in boxes and handled by the machinery mentioned above. All excavation below a depth of 4 to 6 ft. had to be picked, except a small portion on Manchester Ave. and at the west end, and much of the hard clay and shale had to be blasted.

An air compressor was installed at about Sta. 9, a 9x11-in. compressor, driven by a 30-hp. motor. The air lines were laid from Sta. 0 to 25, the longest line being 1600 ft., part 2½-in. and part 1-in. pipe.

In solid rock work, the plans called for a 9-in. concrete wall and payment was made on that basis but no attempt was made to cut the rock to a smooth face. The rock as taken out varied from 4 in. inside the 9-in. line to 6 in. or more outside, the amount of concrete actually used checking very closely with the amount in the 9-in. wall. The surface was left as rough as possible to secure a good bond between the concrete and rock.

The sewer section was built in four stages. First, the concrete smoothing layer in the bottom was placed, a small profile or templet being used at the forward end of the section. The vitrified brick wearing course in the bottom, laid on this concrete, was bedded in a ½-in. layer of 1:3 dry mortar and grouted with 1:2 mortar.

The side-wall forms were made of wood in full sections for a 16-ft. length. The two side pieces were handled with the derrick or cable, set true to line and braced together. The concrete for the walls was made very wet and was thoroughly rammed and spaded during placing. Both walls for a 16-ft. length were brought up full height at one time. A slightly dryer mix was used at the top of the walls to form the skewbacks for the arch. The center of the brick arch, usually 8 ft. long, rested on wedges on the top of the sidewall forms. The first 8 ft. of arch, for a 16-ft. section was laid and the center dropped immediately for use on the second 8 ft. Very little difference can be noted between the arches in which the center was pulled before initial set of the mortar and those under which the forms were left for several days.

Fig. 4 is a view of the smaller section in rock. The amount of concrete per foot was nowhere sufficient to warrant the use of a mixer, so all the mixing was done by hand. Flexible spouts were used, into which the concrete was shoveled. The concrete dropped through the spouts directly into the side walls with considerable force and the spouts were moved continuously along the walls, keeping concrete level and preventing a separation of the mortar from the stone.

Shortly after the work was begun a crusher was installed, near the compressor already mentioned, and on the edge of the private quarry. Nearly all of the crushed stone for concrete was made at this point by crushing rock taken from the sewer trench.

Tunnel Section

The tunnel section was worked from three shafts at Sta. 33 + 70, 35 + 96 and 38 + 43, and from the end of the open cut at Sta. 32. The whole tunnel was in a stratum of pure commercial fire clay, except at one or two points, where a soft stone was encountered in the lower portion. The fire clay was overlaid with a tough shale, the plane of division varying from 1 to 3 ft. above the crown of the arch. It was found impracticable to hold this thin layer of fire clay and for a large part of the length the excavation was taken out up to the bottom of the shale and the void over the crown backfilled. Very little timbering was required.

A heading was taken out for the full width from the spring line of the arch to the top of the fire clay. The invert was worked as a bench and was kept a few feet behind the heading. Drilling was done with a breast auger and in some of the harder materials two men were required on a drill, one to turn and one to push. The holes averaged 4 ft. deep, and six or eight were put down per day. Both black powder and dynamite were used, the amount varying from ¼ to ½ lb. to the hole.

For each shift, the force consisted of an engineer and top man on the derrick and seven men underground, three in each heading and the seventh man acting as a straw boss and doing the miscellaneous work. Each gang of three did all the work on the heading, drilling, blasting and loading. The clay was loaded in wooden chain boxes resting on trucks, running on a small track. Loaded boxes were pushed to the shaft and hoisted with a derrick, from which the clay was dumped on a pile, to be sold later.

The poorer clay was left in the heading and used for backfilling over the arch. The average progress of excavation was 3 ft. per day in each heading. The brick layers came in every second or third day and constructed a section of

sewer 6 to 8 ft. long, the excavation being stopped while bricklaying was done.

This work, now complete, cost about $82,000 or $13.60 per lin.ft., which is not above the average for sewers of this capacity on flat grades without rock. The Hoffmann-Hogan Construction Co., of St. Louis, were the contractors, and the work was done under the general direction of the writer.

Concrete Box-girder Sewer

In connection with the unusual concrete sewer sections of the Dale Ave. Joint, a short piece of concrete sewer built in 1910 may be of interest.

This is in the Glaise Creek Sewer District No. 3 in south St. Louis. This district lies on a little plateau which at Grand Ave. drops steeply to the level of the bottom land along Glaise Creek. At this point the surface water has washed a deep ravine which extends back into the high ground several hundred feet, while the bottom of it is only a little above the elevations of the main creek. The greater portion of the ravine is in Blow St. and will have to be filled within a few years. For this reason it was not necessary to drain it by the district sewer, the economical level for which was about 17 ft. above the bottom of the ravine.

An earth fill would have been very expensive and the time allowed for the work was not enough to permit of thorough settlement before constructing the sewer.

Fig. 5. Concrete Box-girder Sewer, St. Louis, Mo.

The design adopted for this work was the hollow concrete girder shown in Figs. 5 and 6. The brick sewer at either end is a 22x33-in. egg shape, and the concrete sewer was made 22x34-in. rectangle with the corners cut off. The girder bridge consists of two 36-ft. spans with a central pier and end footings. The structure was considered as two fixed spans, the concrete sewer being carried beyond the end supports. The resisting moment at the ends was calculated as the couple of the upward reaction under the footing and the weight of sewer and earth fill beyond the footing.

The girders were designed to carry the weight of concrete and water (sewer flowing full), and a triangle of earth on top of the sewer 3 ft. high. This last provision was to allow for loads which might come on the sewer when the ravine was being filled and before the fill had compacted enough to carry the weight of the sewer.

The soil was good clay and spread footings were used at all three points. The channel in the bottom of the ravine carried about 2 ft. of storm-water flow, most of which was taken into the sewers after completion of the work, leaving the ravine practically dry.

No attempt at close designing was made and the steel at some points was arbitrarily increased. For simplicity all bars were made ¾ in. except the column hooping. The center line of the brick sewer follows the center of a 15-ft. alley, but the line of the concrete sewer was changed slightly to bring the sewer under the center of a wooden foot bridge previously constructed. This allowed of using the bridge to partially support the forms and for conveying and placing concrete.

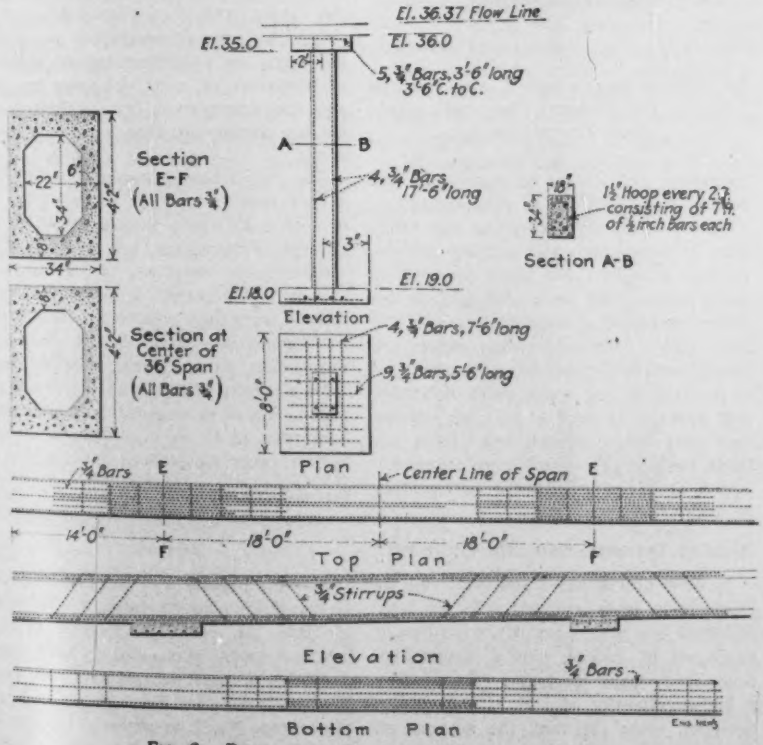

Fig. 6. Details of Concrete Box-girder Sewer

Time Records by Wireless Telegraphy are employed by the Northern Ry. of France for regulating its clocks at St. Quentin, 65 miles from Paris. Every day the Paris Observatory sends a wireless message from the Eiffel Tower at 10:45 a.m., and 10:45 p.m., which can be recorded at distances up to 2500 miles by the use of special collecting apparatus, although only very simple apparatus is required for distances not exceeding 300 miles. The railway company erected a receiving post and connected it with its telegraph office. The time record thus obtained is telegraphed to other stations in order to secure uniformity of the various clocks.

Evaporation from Irrigated Soils

By Samuel Fortier*

In Engineering News of Sept. 19, 1907,† I gave some results of observations made and experiments carried on in California on "Evaporation Losses in Irrigation." Since that time the field of investigation has been extended to other Western states and more data have been secured.

The results obtained in 1908, 1909 and 1910 have been summarized in Bulletin 248, recently published by the Office of Experiment Stations of the U. S. Department of Agriculture, copies of which may be had on application to the Chief of the Division of Publications. The purpose of this article is to present somewhat more in detail a few of the engineering features of this line of investigation.

Need of Economy in Use of Water

In former articles I have called attention to the need of economy in the use of the water supplies of the West. This is still the most vital question which confronts the western half of the United States. It is true water is more economically used now than it was formerly. In irrigation, for example, the same quantity of water now serves a larger area of land; but the necessity of utilizing to the fullest extent possible all the available supply is becoming much greater. This is due to the many useful purposes which water serves, the depletion of the sources of supply and the rapidly increasing value of water rights.

The capacity of conduits which furnish water to towns and cities must keep pace with the growth of urban population, and lawns and shrubbery will soon wither and die in a rainless summer unless copiously watered. The establishment of manufacturing plants has created another use for water, not only in the processes involved in manufacture, but also in generating power to do the work.

By far the largest quantity of water used, however, is for irrigation. One may have a better idea of how large this quantity is if he considers that the volume annually diverted from the streams and other sources of supply in the West for the irrigation of land would cover the entire State of New York to a depth of about 2 ft. During the past season something like 60 million acre-feet of water was taken from streams, reservoirs and underground gravel beds to supplement scanty rainfall in the production of crops.

The most important fact connected with the use of so large a volume of water is its low efficiency. It is reasonably certain that not more than 25% of this total subserves a useful purpose in nourishing plants. The large balance is wasted; but all of such waste can not be prevented. The efficiency of irrigation water resembles that of a centrifugal pump. In poor types of pumps working under unfavorable conditions, the efficiency may fall below 25%, whereas in good types of pumps properly operated, the efficiency may rise above 75%. Even in the best pump there will always be lost energy just as there will always be more or less waste in the use of irrigation water.

The several sources of such waste may be grouped under the following heads: Waste due to faulty laws and regulations regarding the appropriation and use of water, and waste arising from transmission losses, careless or inexperienced irrigators, percolation of water into the subsoil and waste due to evaporation.

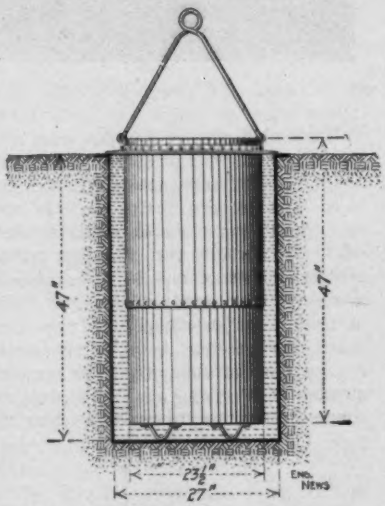

Fig. 1. Galvanized-iron Tanks Used in U. S. Government Soil-evaporation Experiments

The problem of increasing the efficiency of irrigation water is therefore extremely complex; but good progress is being made. Old laws and customs are being remodeled to meet the needs of the arid region. Porous earthen canals are being lined with concrete, the water user is learning to use water more skillfully, less water is allowed to sink beyond the root zone of the plants, and efforts are being made to prevent so large a percentage from escaping into the surrounding atmosphere.

Plan of Investigation and Equipment

In determining the extent and rate of evaporation from irrigated soils we have followed the plan adopted by hydraulic engineers in making similar determinations from water surfaces. By placing a known quantity of soil in a specially designed vessel or tank the amount of water evaporated from its surface in a given time can be determined. By making use of a sufficient number of tanks it was found possible to show also the effect on evaporation of several cultural and irrigation methods of handling soil and applying water. The cultural methods included the maintenance of dry-soil mulches of different depths and shallow and deep cultivation. The irrigation methods included shallow and deep-furrow irrigation, as well as irrigation followed by cultivation. Records were likewise kept for purposes of comparison showing the extent and rate of evaporation from a free-water surface.

In deciding upon the manner of conducting the experiments the field rather than the laboratory was chosen. In working with small units in a laboratory, the determinations can be more accurately made than with large units in a field. It is, however, impossible to maintain conditions in the laboratory as they exist in the open, subject, as they are in the latter case, to continuous and endless variations. The sunshine and fog, heat and wind, which act on the soil of a field can not be made to act in anything like the same way on a sample of soil in a close room.

The equipment of each station consisted of eight galvanized-iron water-jacketed tanks. The inside tanks of each pair were 23½ in. in diameter and the outer tanks 27 in., thus allowing a free space of 1¾ in. on all sides between the tanks. Both inner and outer tanks were 47 in. deep and of the general form shown in Fig. 1. As auxiliary apparatus each station was furnished with facilities for taking and recording meterological data. An attempt was made to secure as nearly as possible complete records of temperatures, wind velocities, rainfall and the evaporation from a free-water surface during the time of each experiment.

The plan followed was to remove from a field about a half ton of soil, place it in a tank as nearly as practicable in its natural surroundings and by periodical weighings to ascertain the amount of moisture evaporated. Irrigation and cultivation were then practiced as the different experiments required, and weighings were made of the inner tank at least twice a week. The losses due to evaporation were first obtained in pounds and later reduced to the equivalent in inches in depth over the surface.

Evaporation Losses from Soils Protected by Mulches of Different Depths

This experiment was conducted at five of the seven stations during the summer of 1908. At each station eight of the jacketed tanks were used. These were divided into four sets of two each and filled with soil, Set No. 1 to within 1 in. of the top, No. 2 to within 4 in., No. 3 to within 7 in. and No. 4 to within 10 in. of the top.

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†See also article by C. H. Lee, Assistant Engineer on the Los Angeles, Calif., Aqueduct, on the soil-evaporation experiments in Owens Valley, Calif., Eng. News, Oct. 12, 1911.

The soil in each tank was then given a 6-in. irrigation, and as soon as the water had disappeared from the soil surface, dry granular soil mulch was added, Set No. 2 receiving a 3-in. layer, Set No. 3 a 6-in. and Set No. 4 a 9-in. layer, thus filling each tank to within 1 in. of the top. Weights were then taken twice a week for a period of three weeks and the losses reduced to inches of water.

The losses recorded at each station were assembled in one table and Fig. 2 is a graphical representation of the results thus obtained and shows a comparison of the amounts lost through the different depth of mulches as well as the percentage loss of water applied. The maximum losses were recorded at Bozeman, Mont., where 2.86 in. of water was lost by evaporation from an unmulched soil surface during the first 21 days after irrigation. From this the losses ranged downward to 0.86 in. at Wenatchee, Wash., during a like period.

The average evaporation from a water surface during the same period, amounting to 5.59 in., followed very closely the variation in wind velocity and temperature, while the losses from the mulched and unmulched soils varied with the moisture content of the soil. The average losses during the first three weeks after irrigating were equivalent to 1.75, 0.75, 0.34 and 0.22 in., respectively, from the unmulched surface, and the surfaces protected by 3-, 6- and 9-in. mulches. These results give a very good general idea of the enormous loss from an unmulched soil surface, and of the large percentage of this absolute loss which can be saved by a thorough mulching of the soil after irrigation.

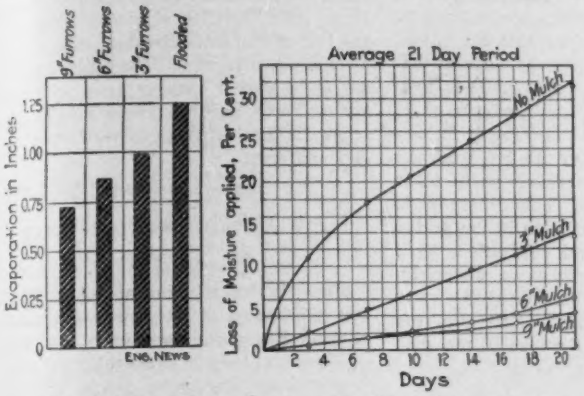


FIG. 2. EVAPORATION LOSSES FROM SOILS PROTECTED BY DIFFERENT DEPTH MULCHES

Of this 1.75 in. loss from a bare surface, 35% was lost in the first three days and over 53% in the first week after irrigation. As soon as the mulches are applied, the moisture due to capillarity starts upward through the soil, and the first losses are small and irregular; but after the first week or ten days the mulch seems to adjust itself and constant losses are recorded for the remainder of the period.

From this and results obtained in subsequent experiments, it is safe to assume that if western soil, containing sufficient moisture to germinate seed and maintain plant growth, be irrigated to a depth of 6 in. and left uncultivated, 1½ to 2 in. of the 6 in. applied will be lost by evaporation in a period of 30 days.

Dry granular soil mulches, 3, 6 and 9 in. deep, such as were used in this experiment, will prevent at least 50, 75 and 80% of this loss. In conclusion it is well to remember that mulches such as these are ideal in regard to their efficiency in checking evaporation, but the nearer they are approached in field cultivation the greater will be the saving, which in itself should be an incentive to deep and thorough cultivation after irrigation.

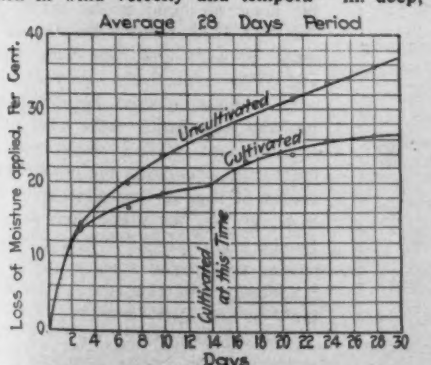


FIG. 4. EVAPORATION LOSSES FROM CULTIVATED AND UNCULTIVATED SOILS

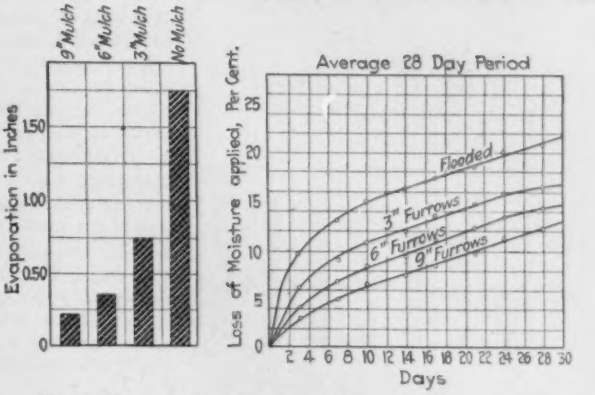


FIG. 3. EVAPORATION LOSSES FROM SOILS IRRIGATED TO DIFFERENT DEPTHS

EVAPORATION LOSSES FROM CULTIVATED AND UNCULTIVATED SOILS

Using the same equipment as in the preceding season, a study was made during May and June, 1909, at each of the seven stations, to determine the losses from cultivated and uncultivated soils.

The tanks were divided into two sets of four each and filled to within 1 in. of their tops with fresh soil. Each of them was then given a 6-in. irrigation (flooded), and as soon as they were sufficiently dry, four of them were cultivated to a depth of 6 in.

In this cultivation it was attempted to approach as nearly as possible actual field conditions. Weighings were made semi-weekly for a period of two weeks, when the soil was again cultivated and the weighings continued for another two weeks. The diagram, Fig. 4, represents graphically these losses and a comparison of the percentages of the six irrigations lost by evaporation.

The losses from the uncultivated soils compare very favorably with that of the previous season, averaging for the 28 days 2.13 in., which is 36% of the 6 in. applied.

The loss from the cultivated surface for the same period amounts to 1.58 in. and shows a saving of over 25% of the loss from the uncultivated soils.

Of the loss from an uncultivated surface 38% of the total occurred in the first three days (the average period between irrigation and cultivation), while the cultivated surface in this same period lost 51% of the total. During these same four weeks an average loss of 9.71 in was recorded from a water surface.

The break in the curve of the cultivated soils at the 14th day mark is due to the second cultivation at that time, an increased loss being shown when the moist soil turned up in cultivation was exposed to evaporation. This does not extend beyond a period of three days

after which the losses become smaller than ever.

Deducting the rainfall from the quantities lost and considering only the period from the time of cultivation, it was found that an average of 54% of the loss from an uncultivated surface was saved by cultivation. Although the actual saving

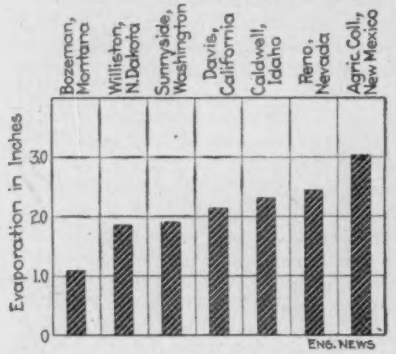


FIG. 5. AVERAGE WEEKLY EVAPORATION FROM WATER SERVICE

of water is but one of the many beneficial features in the consideration of the value of cultivation after irrigation, nevertheless this gives an idea of the magnitude of the losses and to what extent they may be prevented.

EVAPORATION FROM SOILS IRRIGATED TO DIFFERENT DEPTHS

The heavy evaporation losses in the first few days after irrigation has led to the investigation of some method of applying water by which these first heavy losses might be eliminated, and hence the remainder of the season of 1909 (July and August) was devoted to a study of evaporation from soils when the water is applied in furrows of different depths.

The tanks were again divided into four sets of two each and filled with fresh soils all to within 2 in. of the top. A 6-in. irrigation was then given to each of the tanks in the following manner; Set No. 1 flooded, Set No. 2 irrigated in furrows 3 in. deep, Set No. 3 in furrows 6 in. deep and Set No. 4 in furrows 9 in. deep.

The furrows were made crosswise in the tanks and as nearly as possible to conform with actual field conditions. The water was applied slowly to the bottoms of the furrows, and in each case cultivation was practiced as soon as the soil was sufficiently dry. Losses were figured in the usual manner and the average results obtained at Reno and Davis are shown in the diagram Fig. 3, which is similar to those of the previous experiments.

The comparatively light losses shown in all cases are due to the low percentages of moisture in the soil before irrigation, averaging much less than in the cases of the other two experiments. The diagram shows a loss of 1.25, 0.99, 0.86 and 0.72 in. of water from the flooded surface, and the 3-in, 6-in. and 9-in. furrows, respectively, which is 20.8, 16.5, 14.3 and 12% of the 6 in. of water used in irrigation.

At Williston, N. D., under the most favorable conditions for evaporation, and where there was no interference from rainfall, these losses amounted to 2.03, 1.13, 0.74 and 0.62 in., which gives a good idea of the saving which may be accomplished under favorable conditions.

It will be noticed from the diagram that when the saving of water alone is considered, almost the entire advantage is shown in the period immediately following irrigation, and after the first week the percentage curves parallel each other showing equal losses. This difference is mainly due to the variation in the period between irrigation and cultivation, as it was found this period was materially shortened by the application of the water in the deeper furrows. Secondly, the deeper the furrows the less is the area that is exposed to evaporation.

EFFECT OF TEMPERATURE, WIND VELOCITY AND SOIL MOISTURE

In the consideration of evaporation losses from a water surface, the temperature and the wind velocity are generally considered as the controlling factors.

The controlling features in evaporation from soils are: (1) The percentage of moisture in the top layer of the soil; (2) the character and general texture of the soil; (3) the climatology and general weather conditions which control evaporation from a water surface.

Other things being equal the localities of greatest evaporation from a water surface (Fig. 5) would also show the greatest loss from an irrigated soil, but when the character and moisture elements of

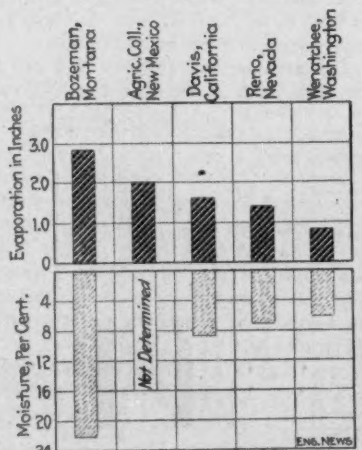


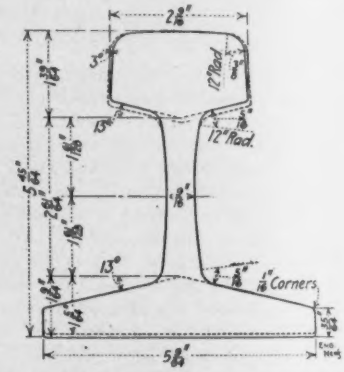
FIG. 6. VARIATION OF EVAPORATION LOSS WITH MOISTURE CONTENT OF SOIL

the soil are considered this is found to be far from true, localities recording greatest losses from a water surface often showing the least losses from the soils, the losses from the latter being controlled almost entirely by the percentage of available moisture in the top layer of the soil.

The diagram Fig. 6, gives a comparison of the percentage of moisture in the soil before irrigation and evaporation losses from the unmulched tanks during the first 21 days after irrigation obtained at the different stations during 1908, and shows their variation with each other regardless of elements favoring evaporation from a water surface. The latter during the same period ranging from 8.02 in. loss at Davis as a maximum to 4.50 in. at Agricultural College of New Mexico, as a minimum.

New 100-lb. Rail Section; C. & N. W. Ry.

Since the investigation of rail sections was commenced by the American Society of Civil Engineers some years ago, the tendency has been to equalize the propor-



NEW 100-LB. RAIL SECTION; CHICAGO & NORTHWESTERN RY.

[The dotted lines show the 100-lb. rail of the American Railway Association type ("B" section)]

tions of metal in the head and base, thus departing from the old idea of putting a big mass of metal in the head. In the Am. Soc. C. E. section the proportions of metal in head and base were made 42 and 37%, respectively. In the more recent sections adopted by the American Railway Association these were modified to 40.1 and 40.7%, respectively, thus practically equalizing the proportions. In a type of section now adopted by the C. & N. W. Ry. the proportions are 36.1% for the head and 44.2% for the base, thus putting the greater mass in the base and practically reversing the proportions of the Am. Soc. C. E. sections.

The comparatively new type of rail section adopted by the American Railway Association has demonstrated its superiority to the earlier Am. Soc. C. E. type of section under the severe conditions of modern railway service, as noted in our issue of Aug. 1. The A. R. A. section, however, has not been accepted universally as the best type of section, and an important modification

has been made by Mr. Carter, Chief Engineer of the Chicago & Northwestern Ry., in a new section of 100-lb. rail for that road. In this section the proportion of metal in the head is reduced and that in the base is increased, as noted above. The accompanying cut shows this new section in comparison with the A. R. A. section of the same weight, and the table shows a comparison of the proportions.

For the past two years this railway has been purchasing the 100-lb. ("B" section) rail of the A. R. A. type. The special feature of the modification made in the new section consists in substituting the head of the 90-lb. rail, and disposing of the surplus metal of the 100-lb. head in thickening the base of the 100-lb. section. The addition to the base is exactly $\frac{1}{2}$ in. thick. It was considered that the resultant section would roll just as well as the old section; and that on account of the increased mass in the base it would require less hot cambering. Therefore, it would be likely to become more nearly straight in cooling, thus reducing the amount of cold straightening required for producing perfectly true rails. The reason for thickening the base was that a large proportion of rail failures during the early part of the past winter were due to moon-shaped sections breaking out of the flange, and it was considered that added metal in the flange would tend to materially (if not entirely) eliminate fractures of this character.

The rolling of rails of this section at the Gary plant of the United States Steel Co. has justified the opinion that they would require less cold straightening, and has been very satisfactory. The C. & N. W. Ry. commenced receiving the new rail in May, on an order of 33,000 tons to be delivered this year. So far it has received and laid 3500 tons in the main line.

COMPARISON OF 100-LB. RAIL SECTIONS

	C. & N. W. Ry.	A. R. A. ("B")	Am. Soc. C. E.
Height	5⅝	5⅝	5¼
Width of base	5½	5½	5¼
Area of head: sq.in.	3.56	3.95	...
Web	1.94	1.89	...
Base	4.35	4.01	...
Total	9.85	9.85	...
Proportions: Head, %	36.10	40.10	42
Web, %	19.70	19.20	21
Base, %	44.20	40.70	37

American Automobiles Exported in the fiscal year 1912 reached a value of about $30,000,000, against less than $1,000,000 in 1902. The average value of cars has gradually decreased, being $1880 in 1908, $1700 in 1909, $1380 in 1910, $1100 in 1911 and $990 in 1912. Automobile imports for 1912 amounted in value to about $2,000,000, against $4,000,000 in 1907, and the average value of cars is increasing, being $1788 in 1909, $1936 in 1910, $2138 in 1911 and $2216 in 1912. A summary would indicate an increasing export of cheap cars and a decreasing import of expensive cars, and of interest in this connection are the census reports for 1900 and 1910, showing an increase in value of cars manufactured from $4,748,000 in 1899 to $249,202,000 in 1909.

Vertical Curves, Spirals, and Connecting Spirals for Meter-Gage Railways

By Lee Fraser*

The following tables and instructions for laying out vertical curves, spirals and connecting spirals, are published by the Antofogasta & Bolivia Ry. Co., for the use of its engineers. The spirals are direct adaptions of the Searles spiral for use on meter-gage lines.

Vertical Curves

Vertical curves are to be staked out where the algebraic difference of gradients exceeds two-tenths per cent. (0.2%), and where tangents of adjacent grades will permit they are to be 20 m. long for each tenth per cent. algebraic difference of gradients. See Fig. 1.

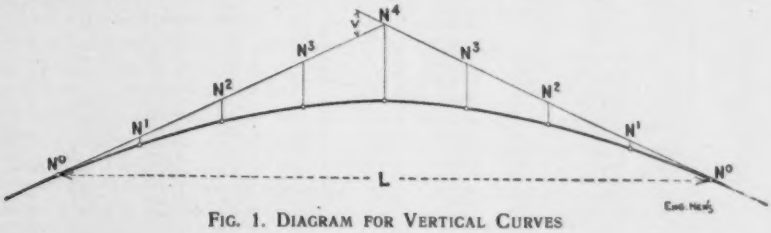


Fig. 1. Diagram for Vertical Curves

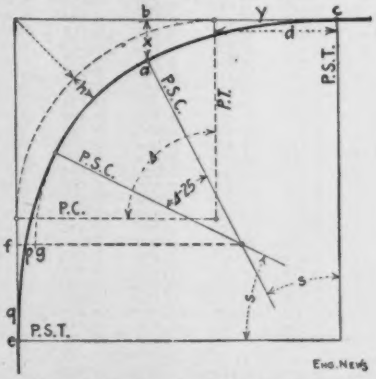


Fig. 2. Diagram for Spiral Curves

V = Total change in gradient at vertex (algebraic difference of gradients).

L = Length of curve in 20-m. stations.

V/L = Average change per station in gradient on curve N-0, N-1, N-2, N-3, N-4, N-5, = Stations numbered from each end of the curve to vertex.

To determine the length of a vertical curve, divide the total change in gradient V by the approximate average change in gradient per station that is desired. Take the nearest even number of stations for the proposed length. Divide V by L for true change per station. Then calculate tangent grades from N-0 to vertex, and make the proper deductions for curve elevations, as shown in Table I opposite V/L. Grade corrections for intermediate values of V/L may be found by interpolation, or multiply V/L by the constant at the end of the table.

Spiral

The transition from a tangent to a curve will be made by a spiral when the rate of curvature exceeds 1° 30′ (see Fig. 2).

Definitions:

D = Degree of curve.
R = Radius.
Δ = Total intersection angle.
S = Central angle of spiral.
h = Difference between externals of transition and simple curves.
$P.S.T.$ = Point of spiral and tangent.
$P.S.C.$ = Point of spiral and curve.
$x = ab$ = Abscissa of $P.S.C.$
$y = bc$ = Ordinate of $P.S.C.$
g = Intersection of circular curve produced and radius perpendicular to tangent.
$p = fg$ Abscissa of point g.
$q = ef$ Ordinate of point g.
N = Number of chords in spiral.
C = Length of chords.
T = Semi-tangent of regular curve.
$d + T$ = Semi-tangent of regular curve with spiral at both ends.

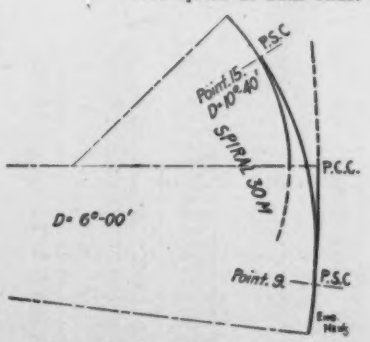


Fig. 3. Diagram for Spiral Curve Connections

L = Curve with spiral at one end, semi-tangent at end with spiral.

M = Curve with spiral at one end, semi-tangent at end without spiral.

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TABLE I. VERTICAL CURVES

(The figures in each column are decimals of meters).

V/L	N¹	N²	N³	N⁴	N⁵	N⁶	N⁷	N⁸	N⁹	N¹⁰	N¹¹	N¹²	N¹³	N¹⁴	N ¹⁵
0.040	0.004	0.016	0.036	0.064	0.100	0.144	0.196	0.256	0.324	0.400	0.484	0.576	0.676	0.784	0.900
0.041	0.004	0.016	0.037	0.066	0.103	0.148	0.201	0.262	0.332	0.410	0.496	0.590	0.693	0.804	0.923
0.042	0.004	0.017	0.038	0.067	0.105	0.151	0.206	0.269	0.340	0.420	0.508	0.605	0.710	0.823	0.945
0.043	0.004	0.017	0.039	0.069	0.108	0.155	0.211	0.275	0.348	0.430	0.520	0.619	0.727	0.843	0.968
0.044	0.004	0.018	0.040	0.070	0.110	0.158	0.216	0.282	0.356	0.440	0.532	0.633	0.744	0.862	0.990
0.045	0.005	0.018	0.041	0.072	0.113	0.162	0.221	0.288	0.365	0.450	0.545	0.648	0.761	0.882	1.013
0.046	0.005	0.018	0.041	0.074	0.115	0.166	0.225	0.294	0.378	0.460	0.557	0.662	0.777	0.902	1.035
0.047	0.005	0.019	0.042	0.075	0.118	0.169	0.230	0.301	0.381	0.470	0.569	0.677	0.794	0.921	1.058
0.048	0.005	0.019	0.043	0.077	0.120	0.173	0.235	0.307	0.389	0.480	0.581	0.691	0.811	0.941	1.080
0.049	0.055	0.020	0.044	0.078	0.123	0.176	0.240	0.314	0.397	0.490	0.593	0.706	0.828	0.960	1.103
0.050	0.005	0.020	0.045	0.080	0.125	0.180	0.245	0.320	0.405	0.500	0.605	0.720	0.845	0.980	1.125
0.051	0.005	0.020	0.046	0.082	0.128	0.184	0.250	0.326	0.143	0.510	0.617	0.734	0.862	1.000	1.148
0.052	0.005	0.021	0.047	0.083	0.130	0.187	0.255	0.333	0.421	0.520	0.629	0.749	0.879	1.019	1.170
0.053	0.055	0.021	0.048	0.085	0.133	0.191	0.265	0.339	0.429	0.530	0.641	0.763	0.896	1.039	1.193
0.054	0.005	0.022	0.049	0.086	0.135	0.194	0.270	0.346	0.437	0.540	0.643	0.778	0.913	1.058	1.215
0.055	0.006	0.022	0.050	0.088	0.138	0.198	0.274	0.352	0.446	0.550	0.666	0.792	0.930	1.078	1.238
0.056	0.006	0.022	0.050	0.090	0.140	0.202	0.279	0.358	0.454	0.560	0.678	0.806	0.946	1.098	1.260
0.057	0.006	0.023	0.051	0.091	0.143	0.205	0.284	0.365	0.462	0.570	0.690	0.821	0.963	1.117	1.283
0.058	0.006	0.023	0.052	0.093	0.145	0.209	0.289	0.371	0.470	0.580	0.702	0.835	0.980	1.137	1.305
0.059	0.006	0.024	0.053	0.094	0.148	0.212	0.294	0.378	0.478	0.590	0.714	0.850	0.997	1.156	1.328
0.060	0.006	0.024	0.054	0.096	0.150	0.216	0.299	0.384	0.486	0.600	0.726	0.864	1.014	1.176	1.350
0.061	0.006	0.024	0.055	0.098	0.153	0.220	0.304	0.390	0.494	0.610	0.738	0.878	1.031	1.196	1.373
0.062	0.006	0.025	0.056	0.099	0.155	0.223	0.309	0.397	0.502	0.620	0.750	0.893	1.048	1.215	1.395
0.063	0.006	0.025	0.057	0.101	0.158	0.227	0.314	0.403	0.510	0.630	0.762	0.907	1.065	1.235	1.418
0.064	0.006	0.026	0.058	0.102	0.160	0.230	0.319	0.410	0.518	0.640	0.775	0.922	1.082	1.254	1.440
0.065	0.007	0.026	0.059	0.104	0.163	0.234	0.323	0.416	0.527	0.650	0.787	0.936	1.099	1.274	1.463
0.066	0.007	0.026	0.059	0.106	0.165	0.238	0.323	0.422	0.535	0.660	0.799	0.950	1.115	1.294	1.485
0.067	0.007	0.027	0.060	0.107	0.168	0.241	0.328	0.429	0.543	0.670	0.811	0.965	1.132	1.313	1.508
0.068	0.007	0.027	0.061	0.109	0.170	0.245	0.333	0.435	0.551	0.860	0.823	0.979	1.149	1.333	1.530
0.069	0.007	0.028	0.062	0.110	0.173	0.248	0.338	0.442	0 559	0 680	0.835	0.994	1.166	1.352	1.553
0.070	0.007	0.028	0.063	0.112	0.175	0.252	0.343	0.448	0.567	0.700	0.847	1.008	1.183	1.372	1.575
0.071	0.007	0.028	0.064	0.114	0.178	0.256	0.348	0.454	0.575	0.710	0.859	1.022	1.200	1.392	1.599
0.072	0.007	0.029	0.065	0.115	0.180	0.259	0.353	0.461	0.583	0.720	0.871	1.037	1.217	1.411	1.620
0.073	0.007	0.029	0.066	0.117	0.183	0.263	0.358	0.467	0.591	0.730	0.883	1.051	1.234	1.431	1.643
0.074	0.007	0.030	0.067	0.118	0.185	0.266	0.363	0.474	0.599	0.740	0.895	1.066	1.251	1.450	1.665
0.075	0.008	0.030	0.068	0.120	0.188	0.270	0.368	0.480	0.608	0.750	0.908	1.080	1.268	1.470	1.688
0.076	0.008	0.030	0.068	0.122	0.190	0.274	0.372	0.486	0.616	0.760	0.920	1.094	1.284	1.490	1.710
0.077	0.008	0.031	0.069	0.123	0.193	0.277	0.377	0.493	0.624	0.770	0.932	1.109	1.301	1.509	1.733
0.078	0.008	0.031	0.070	0.125	0.195	0.281	0.382	0.499	0 632	0.780	0.944	1.123	1.318	1.529	1.755
0.079	0.008	0.032	0.071	0.126	0.198	0.284	0.387	0.506	0.640	0.790	0.956	1.138	1.335	1.548	1.787
0.080	0.008	0.032	0.072	0.128	0.200	0.288	0.392	0.512	0.648	0.800	0.968	1.152	1.352	1.568	1.800
0.081	0.008	0.032	0.073	0.130	0.203	0.292	0.397	0.518	0.656	0.810	0.980	1.166	1.369	1.588	1.823
0.082	0.008	0.033	0.074	0.131	0.205	0.295	0.402	0.525	0.064	0.820	0.992	1.181	1.386	1.607	1.845
0.083	0.008	0.033	0.075	0.133	0.208	0.299	0.407	0.531	0.672	0.830	1.004	1.195	1.403	1.627	1.808
0.084	0.008	0.034	0.076	0.134	0.210	0.302	0.412	0.538	0.680	0.840	1.017	1.210	1.420	1.646	1.890
0.085	0.009	0.034	0.077	0.136	0.213	0.306	0.417	0.544	0.689	0.850	1.029	1.224	1.437	1.666	1.913
0.086	0.009	0.034	0.077	0.138	0.215	0.310	0.421	0.550	0 697	0.860	1.041	1.238	1.453	1.686	1.935
0.087	0.009	0.035	0.078	0.139	0.218	0.313	0.426	0.557	0.705	0.870	1.053	1.253	1.470	1.705	1.958
0.088	0.009	0.035	0.079	0.141	0 220	0 317	0.431	0.563	0 713	0.880	1.065	1.267	1.487	1.725	1.980
0.089	0.009	0.036	0.380	0.142	0.223	0.320	0.436	0.570	0.721	0.890	1.077	1.282	1.504	1.744	2 003
0.090	0.009	0.036	0.081	0.144	0.225	0.324	0.441	0.576	0 729	0.900	1.089	1.296	1.521	1.764	2 025
0.091	0.009	0.036	0.082	0.146	0.228	0.328	0.446	0.582	0.737	0 910	1.101	1.310	1.538	1.784	2 048
0.092	0.009	0.037	0.083	0.147	0.230	0.331	0.451	0.589	0.745	0.920	1.113	1.325	1.555	1.803	2 070
0.093	0.009	0.037	0.084	0.149	0.233	0.335	0.456	0.595	0.753	0.930	1.125	1.339	1.572	1.823	2.093
0.094	0.009	0.038	0.085	0.150	0.235	0.338	0.461	0.602	0.761	0.940	1.137	1.354	1.589	1.842	2.115
0.095	0.010	0.038	0.086	0.152	0 238	0.342	0.466	0.608	0.770	0.950	1.150	1.368	1.6C6	1.862	2 138
0.096	0.010	0.038	0.086	0.154	0.240	0.346	0.470	0.614	0.778	0.960	1.162	1.382	1.622	1.882	2.160
0.097	0.010	0.039	0.087	0.155	0.243	0.349	0.475	0.621	0 786	0.970	1.174	1.397	1.639	1.901	2.183
0.098	0.010	0.039	0.088	0.157	0.245	0.353	0.480	0.627	0.794	0.980	1.186	1.411	1.656	1.921	2 205
0.099	0.010	0.040	0.089	0.158	0.248	0.356	0.485	0.634	0.802	0.990	1.198	1.426	1.673	1.940	2 228
0.100	0.010	0.040	0.090	0.160	0.250	0.360	0.490	0.640	0.810	1.000	1.210	1.440	1.690	1.960	2 250
0.101	0.010	0.040	0.091	0.162	0.253	0.364	0.495	0.646	0.818	1.010	1.222	1.454	1.707	1.980	2.273
0.102	0.010	0.041	0.092	0.163	0.255	0.367	0.500	0.653	0.826	1.020	1.234	1.469	1.724	1.999	2 295
0.103	0.010	0.041	0.093	0.165	0.258	0.371	0.505	0.659	0.834	1.030	1.246	1.483	1.741	2.019	2 318
0.104	0.010	0.042	0.094	0.166	0.260	0.374	0.510	0.666	0.842	1.040	1.258	1.498	1.758	2.038	2.340
0.105	0.011	0.042	0.095	0.168	0.263	0.378	0.515	0.672	0.851	1.050	1.271	1.512	1.775	2.058	2.363
0.106	0.011	0.042	0.095	0.170	0.265	0.382	0.519	0.678	0.859	1.060	1.283	1.526	1.791	2.078	2.385
0.107	0.011	0.043	0.096	0.171	0.268	0.385	0.524	0.685	0.867	1.070	1.295	1.541	1.808	2.097	2.408
0.108	0.011	0.043	0.097	0.173	0.270	0.389	0.529	0.691	0.875	1.080	1.307	1.555	1.825	2.117	2.430
0.109	0.011	0.044	0.098	0.174	0.273	0.392	0.534	0.698	0.883	1.090	1.319	1.570	1.842	2.136	2.453
0.110	0.011	0.044	0.098	0.176	0.275	0.396	0.539	0.704	0.891	1.100	1.331	1.584	1.859	2.166	2.475
Constant Diff.	0.0001	0.0004	0.0009	0.0014	0.0025	0.0036	0.0049	0.0064	0.0081	0.0100	0.0121	0.0144	0.0169	0.0196	0.0225

TABLE II. SPIRAL FUNCTIONS IN METERS

D	N:C	S	Q	P	X	Y	L S	D	N:C	S	Q	P	X	Y	L S
1°30′	2:6.6	0°30′	6.53	0.02	0.05	13.20	13.2	8°	9:4.2	7°30′	19.02	0.51	1.74	37.73	37.8
2°	3:6.6	1°00′	9.80	0.05	0.13	19.80	19.8	8°30′	13:5.4	15°10′	34.39	1.70	6.40	69.69	70.2
2°	2:5.0	0°30′	5.00	0.02	0.04	10.00	10.0	8°30′	11:4.6	11°00′	24.66	0.90	3 38	50.41	50.6
2°30′	4:6.6	1°40′	13.07	0 09	0.29	26.40	26.4	8°30′	9:4.0	7°30′	18.32	0.50	1.66	35.94	36.0
2°30′	3:4.8	1°00′	6.40	0.03	0.10	14.40	14.4	9°	13:5.2	15°10′	33.76	1.72	6.16	65.11	67.6
3°	5:6.6	2°30′	16.33	0.16	0.53	32 99	33.0	9°	12:4.8	13°00′	28.62	1.25	4.52	57.29	57.6
3°	3:4.4	1°00′	6.53	0.03	0.09	13.20	13 2	9°	9:3.8	7°30′	17.50	0.48	1 57	34 14	34 2
3°30′	6:6.6	3°30′	19.59	0.26	0.87	39.58	39.6	9°30′	14:5.2	17°30′	35.79	2.04	7.63	72.10	72.8
3°30′	4:4.8	1°40′	9.67	0.07	0.21	19.20	19 2	9°30′	13:4.8	15°10′	30.35	1.48	5.69	61.95	62 4
3°30′	3:3.4	1°00′	4.49	0.02	0.07	10.20	10.2	9°30′	10:3.8	9°10′	18.66	0.58	2.12	37.90	38 0
4°	7:6.6	4°40′	22.86	0.39	1.34	46.17	46.2	10°	14:5.0	17°30′	34.83	2.02	7.33	69.33	70 0
4°	5:4.8	2°30′	11.50	0.11	0.38	24.00	24.0	10°	13:4.6	15°10′	29.35	1.46	5.45	59.37	59.8
4°	4:4.0	1°40′	7.66	0.05	0.17	16.00	16.0	10°	10:3.6	9°10′	17.63	0.55	2.01	35.90	36.0
4°30′	8:6.6	6°00′	26.11	0.56	1.96	52.74	52.8	10°30′	15:5.0	20°00′	36.68	2.35	8.94	74 06	75 0
4°30°	7:5.6	4°40′	18.45	0.30	1.14	59.17	39.2	10°30′	13:4.4	15°10′	28.19	1.41	5.22	56 79	57 2
4°30′	5:4.4	2°30′	10.89	0.11	0.35	22.00	22.0	10°30′	10:3.4	9°10′	16.50	0.50	1.90	33.91	34.0
5°	9:6.6	7°30′	29.37	0.77	2.73	59.29	59.4	11°	15:4.8	20°00′	35.42	2.29	8.58	71.10	72 0
5°	8:5.8	6°00′	22.38	0.46	1.72	46.35	46.4	11°	13:4.0	15°10′	24.33	1.11	4.74	51.62	52 0
5°00′	6:4.6	3°30′	13.59	0.18	0.61	27.59	27.6	11°	10:3.2	9°10′	15.29	0.46	1.79	31.91	32 0
5°30′	10:6.6	9°10′	32.62	1.03	3.69	65.82	66.0	11°30′	16:4.8	22°40′	37.11	2.62	10.33	75.57	76 8
5°30′	8:5.4	6°00′	21.36	0.46	1.60	43.15	43.2	11°30′	14:4.2	17°30′	28.22	1.54	6.16	58.24	58 8
5°30′	7:4.8	4°40′	16.62	0.29	0.98	33.58	33.6	11°30′	11:3.2	11°00′	16.02	0.71	2.35	35.07	35 2
6°	11:6.6	11°00′	35.86	1.33	4.84	72.32	72.6	12°	16:4.8	22°40′	38.70	2.94	10.33	75 57	76 8
6°	10:6.0	9°10′	29.40	0.91	3.35	59.84	60.0	12°	14:4.2	17°30′	29.47	1.73	6.16	58.24	58 8
6°	8:5.0	6°00′	19.98	0.44	1.48	39.95	40.0	12°	11:3.4	11°00′	19.00	0.74	2.50	37.26	37 4
6°30′	11:6.2	11°00′	34.28	1.31	4.55	67.94	68.2	12°30′	17:4.8	25°30′	40.41	3.34	12.29	79.95	81 6
6°30′	10:5.6	9°10′	27.75	0.88	3.13	55.85	56.0	12°30′	15:4.2	20°00′	30.80	1.97	7.51	62.21	63 0
6°30′	7:4.0	4°40′	13.63	0.23	0.81	27.98	28.0	12°30′	12:3.4	13°00′	19.92	0.85	3.20	40.58	40 8
7°	12:6.2	13°00′	37.15	1.54	5.84	74.00	74.4	13°00′	17:4.4	25°30′	35.26	2.66	11.26	73.29	74 8
7°	10:5.2	9°10′	25.77	0.81	2.91	51.86	52.0	13°	15:4.0	20°00′	29.04	1.82	7.15	59.25	60 0
7°	8:4.2	6°00	16.44	0.35	1.25	33.56	33.6	13°	12:3.0	13°00′	15.94	0.56	2.82	35.81	46 0
7°30′	12:5.8	13°00′	34.83	1.54	5.46	69.23	69.6	14°	18:4.4	28°30′	38.06	3.32	13.26	77.21	79 2
7°30′	11:5.2	11°00′	27.81	1.01	3.82	56.98	57.2	14°	16:3.8	22°40′	28.21	1.84	8.18	59.83	60 8
7°30′	9:4.4	7°30′	19.57	0.51	1.82	39.53	39.6	14°	14:3.4	17°30′	22.47	1.19	4.99	47.14	47 6
8°	12:5.4	13°00′	32.21	1.41	5.09	64.45	64.8	15°	18:4.2	28°30′	37.14	3.37	12.66	73.70	75 6
8°	11:5.0	11°00′	27.44	1.04	3.67	54.79	55.0	15°	15:3.6	20°00′	27.12	1.82	6.44	53.32	54 0

TABLE IV. SPIRAL DEFLECTIONS

—	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	0°03′	0°13′	0°23′	0°38′	0°55′	1°16′	1°40′	2°07′	2°38′	3°12′	3°50′	4°31′	5°15′	6°02′	6°53′	7°47′	8°44′	9°45′	0°48′	11°55′
1	0°05′	1	0°10′	0°23′	0°38′	0°58′	1°20′	1°46′	2°15′	2°47′	3°23′	4°02′	4°45′	5°31′	6°20′	7°12′	8°08′	9°07′	10°09′	11°14′	12°23′
2	0°17′	0°10′	2	0°15′	0°33′	0°53′	1°18′	1°45′	2°16′	2°50′	3°27′	4°08′	4°52′	5°40′	6°31′	7°25′	8°22′	9°23′	10°27′	11°34′	12°14′
3	0°37′	0°27′	0°15′	3	0°20′	0°43	1°08	1°38′	2°10′	2°46′	3°25′	4°07′	4°53′	5°42′	6°35′	7°31′	8°30′	9°32′	10°38′	11°46′	12°59′
4	1°02′	0°52′	0°37′	0°20′	4	0°25′	0°53′	1°23′	1°58′	2°35′	3°16′	4°00′	4°47′	5°38′	6°32′	7°30′	8°31′	9°35′	10°42′	11°52′	13°06′
5	1°35′	1°22′	1°07′	0°47′	0°25′	5	0°30′	1°03′	1°38′	2°18′	3°00′	3°46′	4°35′	5°27′	6°23′	7°22′	8°25′	9°25′	10°40′	11°52′	13°07′
6	2°14′	2°00′	1°42′	1°22′	0°57′	0°30′	6	0°35′	1°13′	1°53′	2°38′	3°25′	4°16′	5°10′	6°07′	7°08′	8°12′	9°20′	10°30′	11°44′	13°02′
7	3°00′	2°44′	2°25′	2°02′	1°37′	1°07′	0°35′	7	0°40′	1°23′	2°08′	2°58′	3°50′	4°46′	5°45′	6°47′	7°43′	9°02′	10°15′	11°30′	12°49′
8	3°53′	3°35′	3°14′	2°50′	2°22′	1°52′	1°17′	0°40′	8	0°45′	1°33′	2°23′	3°18′	4°15′	5°16′	6°20′	7°27′	8°38′	9°52′	11°10′	12°30′
9	4°52′	4°33′	4°10′	3°44′	3°15′	2°42′	2°07′	1°27′	0°45′	9	0°50′	1°43′	2°38′	2°38′	4°40′	5°46′	6°55′	8°07′	9°23′	10°42′	12°05′
10	5°58′	5°37′	5°13′	4°45′	4°14′	3°40′	3°02′	2°22′	1°37′	0°50′	10	0°55′	1°53′	2°53′	3°58′	5°05′	6°16′	7°30′	8°47′	10°08′	11°32′
11	7°10′	6°48′	6°22′	5°53	5°20′	4°44′	4°05′	3°22′	2°37′	1°47′	0°55′	11	1°00′	2°03′	3°08′	4°18′	5°30′	6°46′	8°05′	9°27′	10°53′
12	8°29′	8°05′	7°38′	7°07′	6°33′	5°55′	5°14′	4°30′	3°42′	2°52′	1°57′	1°00′	12	1°05′	2°13′	3°23′	4°38′	5°55′	7°16′	8°40′	10°07′
13	9°53′	9°29′	9°00′	8°28′	7°52′	7°13′	6°30′	5°44′	4°55′	4°02′	3°07′	2°07′	1°05′	13	1°10′	2°23′	3°38′	4°58′	6°20′	7°46′	9°15′
14	11°28′	11°00′	10°29′	9°55′	9°18′	8°37′	7°53′	7°05′	6°14′	5°20′	4°22′	3°22′	2°17′	1°10′	14	1°15′	2°33′	3°53′	5°78′	6°45′	8°16′
15	13°07′	12°38′	12°05′	11°29′	10°50′	10°08′	9°22′	8°33′	7°40′	6°44′	5°45′	4°42′	3°37′	2°27′	1°15′	15	1°20′	2°43′	4°08′	5°38′	7°10′
16	14°53′	14°22′	13°48′	13°10′	12°29′	11°45′	10°58′	10°07′	9°13′	8°15′	7°14′	6°10′	5°02′	3°52′	2°37′	1°20′	16	1°25′	2°53′	4°23′	5°55′
17	16°46′	16°13′	15°37′	14°58′	14°15′	13°29′	12°40′	11°48′	10°52′	9°53′	8°50′	7°44′	6°35′	5°22′	4°07′	2°47′	1°25′	17	1°30′	3°03′	4°38′
18	18°45′	18°11′	17°33′	16°52′	16°08′	15°20′	14°30′	13°35′	12°38′	10°37′	10°33′	9°25′	8°14′	7°00′	5°42′	4°22′	2°57′	1°30′	18	1°35′	3°13′
19	20°52′	20°16′	19°36′	18°54′	18°08′	17°18′	16°26′	15°30′	14°30′	13°28′	12°22′	11°13′	10°00′	8°44′	7°25′	6°02′	4°37′	3°07′	1°35′	19	1°40′
20	23°05′	22°27′	21°46′	21°01′	20°14′	19°23′	18°28′	17°31′	16°30′	15°25′	14°18′	13°07′	11°53′	10°35′	9°14′	7°50′	6°22′	4°52′	3°17′	1°40′	20

TABLE III. RADIUS, DEFLECTION, ETC: FOR SPIRAL CURVES ON METER GAGE

Deg.	Radius	Log. R.	Defl. per Meter	Tang. Offset	Middle Ordin'e
0°10′	6875.496	3.83730	Min. 25	0.029	0.007
0°20′	3437.752	3.53627	0.50	0.058	0.015
0°30′	2291.838	3.35018	0.75	0.087	0.022
1°	1145.930	3.05916	1.50	0.175	0.044
1°30′	763.966	2.88307	2.25	0.262	0.065
2°	572.986	2.75815	3.00	0.349	0.087
2°30′	458.402	2.66124	3.75	0.436	0.109
3°	382.016	2.58208	4.50	0.524	0.131
3°30′	327.456	2.51515	5.25	0.611	0.153
4°	286.538	2.45718	6.00	0.698	0.175
4°30′	254.714	2.40605	6.75	0.785	0.196
5°	229.256	2.36032	7.50	0.873	0.218
5°30′	208.428	2.31896	8.25	0.960	0.240
6°	191.074	2.28120	9.00	1.047	0.262
6°30′	176.390	2.24647	9.75	1.134	0.284
7°	163.804	2.21433	10.50	1.222	0.306
7°30′	152.898	2.18441	11.25	1.309	0.327
8°	143.356	2.15642	12.00	1.396	0.349
8°30′	134.938	2.13030	12.75	1.483	0.371
9°	127.456	2.10536	13.50	1.570	0.393
9°30′	120.762	2.08193	14.25	1.658	0.415
10°	114.738	2.05970	15.00	1.745	0.437
10°30′	109.288	2.03858	15.75	1.830	0.456
11°	104.334	2.01843	16.50	1.919	0.480
11°30′	99.812	1.99918	17.25	2.006	0.502
12°	95.668	1.98077	18.00	2.093	0.524
12°30′	91.856	1.96311	18.75	2.181	0.546
13°	88.336	1.94614	19.50	2.268	0.568
13°30′	85.080	1.92983	20.25	2.355	0.589
14°	82.056	1.91411	21.00	2.442	0.612
15°	76.610	1.88430	22.50	2.616	0.655

S/LS = Compensation for curvature, percentage to be deducted from maximum grade, equal to one-half compensation for simple curvature.

FORMULAS:

$$d = (q + p) \times tan\ ½\ \Delta$$
$$L = (d + T) - (p; csc\ \Delta)$$
$$p = x - (R{:}versS)$$
$$q = y - (RsinS)$$
$$h = \frac{p}{cos\ 12\ \Delta}$$
$$M = T + (p: csc\ \Delta)$$

CONNECTING SPIRAL

A connecting spiral will be used to join component parts of a compound curve when the difference in the rates of their curvature exceeds 1°.

To join two curves by a spiral: Given a compound curve of $D = 6°$ and $D1 = 10° 40'$. Required to replace the *P.C.C.* by a spiral: Under table of chord lengths for 5.00 m.,— for $N = 9$, $Ds = 6° + -$; and for $N = 16°$, $Ds = 10° 40' + -$. These are the degrees of curve on chord lengths 8-9 and 15-16, respectively; so that to pass from one curve to another, we must use that portion of the spiral between points 9 and 15. The length of the spiral will then be $(nl - n) \times c$, or $(15 - 9) \times 5 = 30.00$ m.

From Table 5, for $n = 9$, $s = 7° 30'$; and for $nl - S = 20°$. The difference, or 12° 30′ is the angle of compound curve spiral, which must be divided proportionally, thus:

From the 6° curve deduct

$$\left(\frac{D}{D+D} \times 12:30\right), or,$$
$$\left(\frac{6}{6+10:40} - \times 12:30\right) or,$$
$$\left(\frac{36}{100} \times 12:30\right), or\ 4°\ 30'.$$

Similarly for 10° 40′ we find 8°. The 4° 30′ calls for 15 m. of 6° curve and the 8° calls for 15 m. of 10° 40′ curve. Hence the spiral is bisected at the *P.C.C.*

To run in the spiral: Measure back 15 m. on the 6° curve from *P.C.C.*, which will give chord point 9, the beginning of the spiral. From tangent at this point make deflections as follows, using table 4: Starting at chord point 9, deflections read to the right as far as chord point 15 (5° 46′). Similarly, if running backward, start at chord point 15, deflections read to the left as far as chord point 9 (6° 44′).

TABLE V. SPIRAL CURVES

Point N	Degree of Curve Ds	Spiral Angle S	Point N	Degree of Curve Ds	Spiral Angle S
	deg. m.	deg. m.		deg. m.	deg. m.
0	0 00	0 00	10	1 40	9 10
1	0 10	0 10	11	1 50	11 00
2	0 20	0 30	12	2 00	13 00
3	0 30	1 00	13	2 10	15 10
4	0 40	1 40	14	2 20	17 30
5	0 50	2 30	15	2 30	20 00
6	1 00	3 30	16	2 40	22 40
7	1 10	4 40	17	2 50	25 30
8	1 20	6 00	18	3 00	28 30
9	1 30	7 30	19	3 10	31 40
			20	3 20	35 00

Ignition of Gas by Electric Lamps—On account of the increasing use of portable electric mine lamps, the U. S. Bureau of Mines recently made preliminary experiments on the ignition of inflammable gases by rupture of the miniature bulbs while the tungsten filaments were incandescent. In all tests the filaments were glowing at the moment when the bulbs were broken. One hundred and thirty-one bulbs were broken in a mixture of natural gas and air combined in the proportion of 8.6% gas and 91.4% air—the most explosive mixture. Also 45 tests were made in gas and air mixtures other than the most explosive and varying from 3 to 12.4% gas. Mixtures containing as little as 5% and as much as 12.4% could be ignited by 1.5-cp. 3.5-volts cut to 0.3-amp. bulbs smashed while burning at rated voltage. Ninety-nine tests at or below rated voltage gave 66 ignitions, or 66%. Thirty tests at above rated voltage gave 12 ignitions, or 40%.

TABLE VI. SPIRAL CURVE FUNCTIONS FOR VARIOUS CHORD LENGTHS (METERS)

Chord Length — 7M

N	NC	Ds
1	7	0°28′34″
2	14	0°57′09″
3	21	1°25′43″
4	28	1°54′17″
5	35	2°22′52″
6	42	2°51′27′
7	49	3°20′01″
8	56	3°48′36″
9	63	4°17′12″
10	70	4°45′47″
11	77	5°14′23″
12	84	5°43′00″
13	91	6°09′36″

Chord Length — 8M

N	NC	Ds
1	8	0°25′00″
2	16	0°50′00″
3	24	1°15′00″
4	32	1°40′00″
5	40	2°05′00″
6	48	2°30′01″
7	56	2°55′01″
8	64	3°20′01″
9	72	3°45′02″
10	80	4°10′03″
11	88	4°35′03″

Chord Length — 5M

N	NC	Ds
1	5	0°40′00″
2	10	1°20′00″
3	15	2°00′00″
4	20	2°40′01″
5	25	3°20′02″
6	30	4°00′03″
7	35	4°40′04″
8	40	5°20′06″
9	45	6°00′09″
10	50	6°40′13″
11	55	7°20′17″
12	60	8°00′22″
13	65	8°40′28″
14	70	9°20′35″
15	75	10°00′43″
16	80	10°40′52″
17	85	11°21′03″

Chord Length — 6M

N	NC	Ds
1	6	0°33′20″
2	12	1°06 40′
3	18	1°40′00″
4	24	2°13′20″
5	30	2°46′41″
6	36	3°20′02″
7	42	3°53′22″
8	48	4°26′44″
9	54	5°00′05″
10	60	5°33′27″
11	66	6°06′49″
12	72	6°40′12″
13	78	7°13′36″
14	84	7°47′00″

Chord Length — 3M

N	NC	Ds
1	3	1°06′40″
2	6	2°13′20″
3	9	3°20′02″
4	12	4°26′44″
5	15	5°33′28″
6	18	6°40′13″
7	21	7°47′01″
8	24	8°53′51″
9	27	10°00′45″
10	30	11°07′41″
11	33	12°14′41″
12	36	13°21′47″
13	39	14°28′56″
14	42	15°36′09″

Chord Length — 4M

N	NC	Ds
1	4	0°50′00″
2	8	1°40′00″
3	12	2°30′00″
4	16	3°20′02″
5	20	4°10′03″
6	24	5°00′05″
7	28	5°50′08″
8	32	6°40′13″
9	36	7°30′18″
10	40	8°20′26″
11	44	9°10′34″
12	48	10°00′44″
13	52	10°50′56″
14	56	11°41′10″
15	60	18°31′26″
16	64	13°81′45″
17	68	14°12′06″
18	72	15°02′29″

Chord Length — 9M

N	NC	Ds
1	9	0°22′13″
2	8	0°44′27″
3	27	1°06′40″
4	36	1°28′53″
5	45	1°51′07″
6	54	2°13′20″
7	63	2°33′34″
8	72	2°57′48″
9	81	3°20′01″
10	90	3°22′15″

Chord Length — 10M

N	NC	Ds
1	10	0°20′00″
2	20	0°40′00″
3	30	1°00′00″
4	40	1°20′00″
5	50	1°40′00″
6	60	2°00′00″
7	70	2°20′00″
8	80	2°40′00″
9	90	3°00′00″

The Calculation of Secondary Stresses in Trusses

By F. E. Turneaure*

In Engineering News of Oct. 5, 1911, F. C. Kunz presents very clearly Prof. Mohr's method of calculating secondary stresses due to rigidity of joints, and discusses very instructively some of the important phases of the subject. In the method of calculation there described the angular deflection τ of each end of each truss member is expressed in terms of the change in slope ψ of the axis of the member and the general angle of twist ϕ of the joint in question. The changes in slope ψ are most readily found by means of a Williott diagram in the manner described by Mr. Kunz. The angles ϕ are then calculated by means of a set of equations, one for each joint, established by placing equal to zero the sum of the bending moments in all the members meeting at a joint (assuming the primary stresses at the joint to be free from eccentricity).

In the selection of a method of analysis of secondary stresses for his own use the writer, after considerable study, adopted the method employed by Winkler as the one which, on the whole, appeared to be the most satisfactory for the purpose. In this method the deflection angles τ of the members meeting at a joint are expressed in terms of the calculated *changes of angles* between the axes of the several members and the deflection angle τ of some one selected member. The values of these reference angles τ (one for each joint) are then solved in the same manner as the values of the angles ϕ in Mr. Kunz's method. The essential differences between the two methods lies in the determination of the *changes in the slopes* of the axes of the members in Mr. Kunz's method as compared to the calculation of the *changes of angles* between these axes in the writer's method. As used by the writer the process is wholly algebraic, although, if desired, the Williott diagram may be employed for a certain part of the work as in Mr. Kunz's method.

The labor required by the two methods is practically the same, but it is believed that the purely algebraic method has some advantages and will be preferred by many calculators. Whichever method may be used, the calculations are not difficult or lengthy; and the subject is one of such great importance that all structural designers should be able on occasion to study the secondary stresses in his structures. In the interest of a wider knowledge of the available methods of such calculation the writer will here outline the method of Winkler and apply it to the same problem solved by Mr. Kunz.

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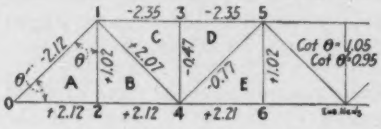
General Method of Solution

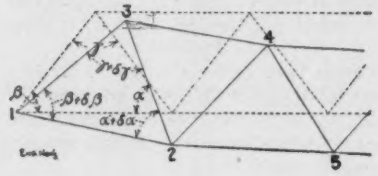
Fundamental Equations—Referring to Mr. Kunz's paper, p. 398, and using generally the same notation, we give here for convenience the general fundamental equations.

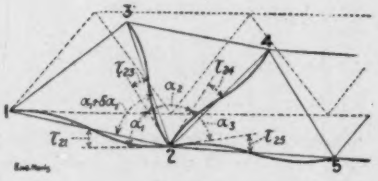
The bending moment M_{12} at joint 1 of member 1-2 is

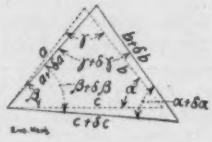
$$M_{12} = \frac{2\,EI}{l}(2\,\tau_{12} + \tau_{21}) = 2\,EK\,(2\,\tau_{12} + \tau_{21}) \qquad (1)$$

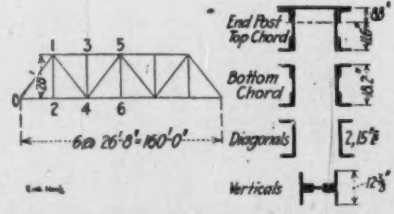
in which $K = \frac{I}{l}$ in general.











The fiber stress f due to the bending moment M is

$$f_{12} = \frac{M_{12}\,e}{I} = \frac{2\,Ee}{l}(2\,\tau_{12} + \tau_{21}) \qquad (2)$$

in which e = distance from neutral axis to extreme fiber.

The sum of the bending moments at joint 2 is

$$\Sigma_2 M = M_{21} + M_{23} + M_{24} + M_{25} = 0 \qquad (3)$$

In these equations the subscript "12" refers to the end of member 1-2 at joint 1, and the subscript "21" refers to the end at joint 2. The writer is accustomed to consider positive values of M such as correspond to counter-clockwise rotation of the joint, as shown in Fig. 3, and this convention will be used here.

Calculation of Changes of Angles Between Axes of Members—Fig. 1 shows by the full lines the distorted position of the axes of the members of a truss. In each triangle, as 1-2-3, the original angles, α, β, γ, become changed by small amounts, designated $\delta\alpha$, $\delta\beta$, and $\delta\gamma$, which amounts depend upon the longitudinal distortions of the several members and upon the proportions of the triangle. Referring to Fig. 2, let δa, δb, and δc be the changes in length of the sides due to the primary stresses. Also let s_a, s_b, and s_c represent these primary stresses, per unit area, in the several members. Then $\delta a = \frac{s_a}{E}a$, $\delta b = \frac{s_b}{E}b$, etc.

We also have by trignometry

$$\delta\alpha = \left(\frac{\delta a}{a} - \frac{\delta b}{b}\right)\cot\gamma + \left(\frac{\delta a}{a} - \frac{\delta c}{c}\right)\cot\beta,$$

whence by substitution,

$$\delta\alpha = \frac{(s_a - s_b)\cot\gamma + (s_a - s_c)\cot\beta}{E} \qquad (4)$$

Equation (4) is general and is used to calculate the desired changes of angle in all the triangles. The value of E may be taken as unity, and again as unity in applying Eq. (2).

The values of $\delta\alpha$ can also readily be found by a Williott diagram, the change of angle $\delta\alpha$ being equal to the difference in the changes in slope ψ of the members b and c.

Values of Deflection Angles τ at a Joint—Having calculated all the changes of angle at each joint we may now express the values of the several deflection angles τ in terms of some particular τ and the known changes of angle at that joint. Thus at joint 2, Fig. 3, if we select τ_{21} as the reference angle we have the following:

$$\left.\begin{aligned}\tau_{23} &= \tau_{21} + \delta\alpha_1\\ \tau_{24} &= \tau_{21} + \delta\alpha_1 + \delta\alpha_2\\ \tau_{25} &= \tau_{21} + \delta\alpha_1 + \delta\alpha_2 + \delta\alpha_3\end{aligned}\right\} \qquad (5)$$

In this manner the number of unknowns is reduced to one for each joint.

Formulation and Solution of Equations for τ. We now, as in Mr. Kunz's method, proceed to write out Eq. (3) for each joint of the truss, expressing the values of the various M's in terms of τ as given in Eq. (1) and Eq. (5). We thus derive as many equations as there are joints, and in them occur as unknowns only the reference angles τ, one for each joint. These equations will be identical with those derived by Mr. Kunz except that the reference angle τ for each joint will appear instead of the general angle of twist ϕ, and the numerical terms will be different. These equations are solved for the values of τ

TABLE I.

Member	Length	Area A sq.in.	Mom. of Iner. I in.⁴	Extreme fiber dist. e in.	Primary stress S 1000 lb.	Unit-stress s = S/A 1000 lb. per sq.in.	K = I/l
0-1	463	47.7	3280	8.8 11.6	—101.	—2.12	7.08
1-3	320	47.7	3280	8.8 11.6	—112.	—2.35	10.25
3-5	320	47.7	3280	8.8 11.6	—112.	—2.35	10.25
0-2	320	33.0	1410	9.1	+69.9	+2.12	4.41
2-4	320	33.0	1410	9.1	+69.9	+2.12	4.41
4-6	320	57.2	1820	9.1	+126.	+2.21	5.69
1-4	463	29.4	805	7.5	+60.8	+2.07	1.74
4-5	463	26.5	750	7.5	—20.3	—.77	1.62
1-2	336	19.7	120	6.2	+20.0	+1.02	0.36
3-4	336	19.7	120	6.2	—9.3	—.47	0.36
5-6	336	19.7	120	6.2	+20.0	+1.02	0.36

and then by adding the proper numerical quantities, as indicated in Eq. (5), we obtain all the deflection angles of all the members. The bending moments are then obtained from (1) or the fiber stresses from (2).

EXAMPLE

The foregoing method will be applied to the problem analyzed by Mr. Kunz (Fig. 4). Table I contains all necessary data regarding dimensions and primary stresses, and the calculated quantity $\frac{I}{l}$ using 1000-lb. units.

TABLE I——

Calculation of Changes of Angle, $\delta\alpha$.—The data for this calculation are conveniently arranged as shown in Fig. 5. The triangles are lettered A, B, etc., and the primary stresses per unit area (s) are written on the members. Then, proceeding by triangles and denoting the angles by the figures at the apexes, we have, from Eq. (4) for triangle A,

$$\delta 0 = (1.02 + 2.12) \times 1.05 = +3.30$$
$$\delta 1 = (2.12 + 2.12) \times 0.95 = +4.03$$
$$\delta 2 = (-2.12 - 2.12) \times 0.95 + (-2.12 - 1.02) \times 1.05 = -7.33$$

and so on for the other triangles. These results are given in Table II in Col. (4), grouped by joints, as far as joint 6.

Formulation of Equations—For each joint we now select a particular τ as the reference angle and express all other deflection angles at that joint in terms of this τ and the changes of angle, as in Eq. (5). This work is shown in Col. (5), Table II. At joint 1, for example, the reference angle τ is taken as τ_{13} (called simply τ_1 for convenience), and the various other deflection angles are found by adding in succession the values of $\delta\alpha$ given in Col. (4). For joint 5 the reference angle is taken as τ_{56} and for joint 6, τ_{65}. By reason of symmetry these angles are zero, hence all values of τ for these joints are given directly in Col. (5).

We now proceed to write out Eq. (3) for each joint, substituting the values of τ from Col. (5). In doing this it is convenient to tabulate in Col. (6) the values of $K\tau$. For joint 0 the equation will be $M_{02} + M_{01} = 0$; or, from (1), omitting the factor $2E$,

$$K(2\tau_{02} + \tau_{20}) + K(2\tau_{01} + \tau_{10}) = 0;$$

or, more conveniently

$$2(K\tau_{02} + K\tau_{01}) + K\tau_{20} + K\tau_{10} = 0.$$

The parenthesis is given by the sum of all the τ's at joint 0, Col. (5), and the other values of $K\tau$ are found opposite the respective members 2-0 and 1-0.

Combining numerical quantities the equation is

$$22.98\,\tau_0 + 7.08\,\tau_1 + 4.41\,\tau_2 = -39.2 \quad (a)$$

Equations for joints 1, 2, 3 and 4 are

$$7.08\,\tau_0 + 38.86\,\tau_1 + 0.36\,\tau_3 + 10.25\,\tau_5 + 1.74\,\tau_4 = -87.0 \quad (b)$$

$$4.41\,\tau_0 + 0.36\,\tau_1 + 18.36\,\tau_2 + 4.41\,\tau_4 = +47.0 \quad (c)$$

$$10.25\,\tau_1 + 41.72\,\tau_3 + 0.36\,\tau_4 = -196.7 \quad (d)$$

TABLE II

Joint	Member	Angle	Change of angle $\delta\alpha$	Value of τ in terms of reference τ	$K\tau$	Calc. value of τ	Bending moment M 1000 in-lb.	Secondary fiber-stress f 1000 lb. per sq.in.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0	0-1			τ_0	$7.08\tau_0$	—1.90	—45.6	—0.12
	0-2	102	+3.30	τ_0+3.30	$4.41\tau_0$+14.6	+1.40	+45.5	+0.29
1	1-3			τ_1	$10.25\tau_1$	—0.83	+38.6	—0.14
	1-4	314	—2.67	τ_1—2.67	$1.74\tau_1$—4.64	—3.50	—18.2	+0.17
	1-2	412	+0.05	τ_1—2.62	$0.36\tau_1$—0.94	—3.45	— 8.6	+0.44
	1-0	210	+4.03	τ_1+1.41	$7.08\tau_1$+10.0	+0.58	—11.9	—0.04
2	2-0			τ_2	$4.41\tau_2$	+2.35	+53.9	+0.35
	2-1	021	—7.33	τ_2—7.33	$0.36\tau_2$—2.64	—4.98	— 9.6	+0.50
	2-4	124	+1.05	τ_2—6.28	$4.41\tau_2$—27.7	—3.93	—44.1	+0.28
3	3-5			τ_3	$10.25\tau_3$	—4.53	—121.	—0.32
	3-4	534	+1.19	τ_3+1.19	$0.36\tau_3$+0.43	—3.33	— 6.6	—0.34
	3-1	431	+6.88	τ_3+8.07	$10.25\tau_3$+82.7	+3.54	+128.	—0.34
4	4-2			τ_4	$4.41\tau_4$	+2.86	+15.8	+0.10
	4-1	241	—1.10	τ_4—1.10	$1.74\tau_4$—1.91	+1.76	+ 0.06	+0.01
	4-3	143	—4.21	τ_4—5.31	$0.36\tau_4$—1.92	—2.45	— 6.0	—0.31
	4-5	345	—1.50	τ_4—6.81	$1.62\tau_4$—11.0	—3.95	—16.4	—0.16
	4-6	546	+1.88	τ_4—4.93	$5.69\tau_4$—28.0	—2.07	+ 6.6	+0.03
5	5-6			0	0	0.00	0.00	0.00
	5-4	654	+2.84	+2.84	+4.60	+2.84	+ 5.6	—0.06
	5-3	453	+0.31	+3.15	+32.3	+3 15	+36.3	—0.10
6	6-5			0	0	0.00	0.00	0.00
	6-4	564	—4.72	+4.72	+26.8	+4.72	+83.8	+0.42

$$1.71\,\tau_1 + 4.41\,\tau_2 + 0.36\,\tau_3 + 27.64\,\tau_4 = +86.1 \quad (e)$$

Comparing these five equations with those of Mr. Kunz in his Table III, it is seen that the numerical coefficients of τ are just one-half of his coefficients of ø (owing to our omission of the factor 2 in the term $2EI$). The absolute terms are entirely different.

Solution of Equations—The direct solution of the five equations is not a long process if the elimination is carried out in the proper order. Thus τ_0 occurs in (a), (b) and (c) only, and should first be eliminated, giving two new equations in place of these three. Then τ_3 will be found to occur in these two new equations and in Eq. (e) only. Eliminating τ_2 gives us two new equations containing τ_1, τ_3 and τ_4, which are then combined with Eq. (d). Generally about five minutes' time is sufficient for each unknown in any single-intersection truss, irrespective of the number of joints or equations, for the number of equations containing any given unknown depends only upon the number of members meeting at the joint in question, being always one more than the number of such members.

The calculated values of τ are as follows: $\tau_0 = -1.90$, $\tau_1 = -0.83$, $\tau_2 = +2.35$, $\tau_3 = -4.53$, $\tau_4 = +2.86$. These are also given in Col. (7) of Table II. The values obtained by Mr. Kunz, found from the relation $\tau = \phi - \psi$, are, respectively, $\tau_0 = -2.1$, $\tau_1 = -0.7$, $\tau_2 = +2.6$, $\tau_3 = -4.56$, $\tau_4 = +2.61$.

The exact method of solution, as employed by the writer, seems to be about as expeditious as the approximate method, although errors are not so readily detected. In solving by successive approximations the writer would suggest a modification of Mr. Kunz's method. In the first approximation the values will be as good or better if all coefficients of τ, except the one sought, be assumed equal to zero. Thus, from Eq. (a) for joint 0, we get at once

$$\tau_0 = \frac{-39.2}{23} = 1.7.$$

Likewise from Eq. (b),

$$\tau_1 = \frac{-87.0}{38.9} = -2.2;$$

so also $\tau_2 = +2.6$ $\tau_3 = -4.6$, and $\tau_4 = +3.1$. Then for a second approximation use Eq. (a) for τ_0 as before, but substitute the above values for τ_1 and τ_2; and so for the other angles. The second approximations thus obtained are: $\tau_0 = -1.5$; $\tau_1 = -0.9$, $\tau_2 = +2.3$, $\tau_3 = -4.2$, and $\tau_4 = +2.8$. A third approximation would be sufficient.

Bending Moments and Stresses—Table II gives in Col. (8) the values of the several bending moments calculated from Eq. (1). They will be seen to agree practically with the values given by Mr. Kunz in his Table IV. If fiber

stresses only are wanted these may be found from Eq. (2) without calculating bending moments.

Approximate Calculation for Continuous Chords in Pin-connected Trusses

In a discussion of the secondary stresses in pin-connected trusses the writer has arrived at essentially the same conclusions as Mr. Kunz.* Eyebars may be assumed as fixed at the ends, and built-up members as hinged. In applying the foregoing method to a continuous top chord, where the web members are connected thereto by means of pins, it is necessary simply to consider the value of $\frac{I}{l}$ or K for all web members as equal to zero. In the foregoing example there will be equations for joints 1 and 3 only, and in these equations only τ_1 and τ_3 will appear as unknowns.

Direct-stress Measurements

The writer has long been interested in the matter of the direct measurement of secondary stresses. While theoretical analysis will undoubtedly give substantially correct results where the true conditions can be taken account of in such analysis, there are many cases where the theoretical method is too complex or uncertain to be practicable. Secondary stresses in the floor system and stresses due to the action of lateral trusses cannot readily be determined by theoretical methods. These stresses are often of importance, and it is very desirable that direct stress measurements should be made along this line. Some progress has recently been made in this work by a committee of the American Railway Engineering Association, of which the writer is a member, and it is expected to continue the observations further. In connection with this general subject it will be of interest to know that in measurements made by this committee in the summer of 1911, by means of extensometers, the results obtained on main trusses as regards bending in vertical planes agreed fairly well with calculated values. More important stresses were found, in many cases, in the floor system and in some members of the main trusses in transverse planes.

A Comprehensive Pension Plan has been announced by the General Electric Co. for its large force of employees. The pension will be 1% of the applicant's average yearly wages for the 10 years preceding retirement, multiplied by the number of years employed, and will be paid to men of 70 and women of 60, who have been 20 years or more in the company's service. Also provision is made for men of 65 and women of 55 who are incapacitated for further work.

*See Johnson, Bryan and Turneaure, Modern Framed Structures, Edition of 1911, Vol. II.

Operations of Dipper and Bucket Dredges Owned by the United States Government

In an article published in Engineering News, for May 9, 1912, describing the operations of the U. S. Government dredging plant, it was stated that in addition to the 23 sea-going hopper and 53 hydraulic pipe-line dredges, the government also owned and operated 61 dipper and bucket dredges. The accompanying table gives the details of the work of 48 of these dredges for the fiscal year ending June 30, 1911, as collated from the Annual Report of the Chief of Engineers, U. S. A.

The table is divided into groups according to the section of the country in which the dredges were at work, the first and largest group of 17 being in the Southern states of Alabama, Georgia, Kentucky, Tennessee and Texas. Another group is of those at work in the Mississippi River and the Great Lakes, and the smaller groups include dredges working on different parts of the Atlantic and Pacific coasts and in the Ohio River; most of those on the Atlantic coast are in the Cape Fear River, North Carolina, and the Waccamaw River, South Carolina, and those on the Pacific coast in the Willamette and Clatskanie rivers in Oregon.

The work done by the 17 dredges enumerated in the first group of the table was mainly the removal of accumulated silt in slack-water streams, and the removal of sand and gravel bars and blasted rock in other streams to maintain low-water depths of from 3 to 6 ft.

The cost of the 17 dredges is given as $265,811, but this is only a small percentage of the dredging plant. The value of the floating plant in the Chattanooga district alone is over a quarter of a million dollars.

Not many data are available for the dredges mentioned in section 2 of the table, which includes the upper Mississippi River, the Great Lakes and tributary rivers and the Illinois and Mississippi canal.

Of the dredges enumerated in the third division of the table, which comprise, rivers in the states of North and South Carolina, the "Ajax" and "Hercules" show the greatest output, a total of 1,108,658 cu.yd. Both are clam-shell dredges, with bucket capacity of 5 and 7 cu.yd., respectively. The dredges were operated during the day throughout the entire year.

So far as can be determined the dredges "Ajax" (Cape Fear River, N. C.), "Carrollton," "Frankfort," "Hercules" and "Sapelo" are the only ones which were operated for the entire year. The Annual Report of the Chief of Engineers only in some few instances gives all the details as to time employed, time lost and time laid up.

The chain-bucket or ladder dredge "Alabama" worked about nine months of the year. It is used exclusively in the maintenance of depths in the canal pools and entrances of the Mussel Shoals canal in the Tennesse River, in Alabama. The dredged material is silt, and the cost of its excavation, 5c. per cu.yd., is low.

In connection with this work it will surprise many readers to know that the United States Government owns and operates a 15-mile railway. This railway runs along the canal bank and is used in connection with the maintenance of the canal. The railway has two locomotives which ran 17,713 miles in the past year at an average cost of 10.9c. per engine-mile.

In the improvement of the Fox River, Wis., between Princeton and Grand River Locks, a conveyor dredging plant was employed during 1910 and 1911. This dredge was the "Oshkosh," of the chain-bucket or ladder type, with belt conveyor for transferring spoil to three auxiliary scows alongside. All conveyors are operated by electric motors. The dredge has 38 buckets of 5 cu.ft. capacity each. The material handled is clay, sand and muck and the cost was only 6c. per cu.yd.

The two dipper dredges "Ohio" and "Oswego" are employed in dredging the Ohio River between Wheeling, W. Va., and Cincinnati, Ohio. The dredging consists of the removal of sand and gravel bars. The usual method of working is to make one, two, three or more cuts, 35 ft. wide, and of lengths from 190 to 2380 ft. The dredged material is dumped along the West Virginia and Ohio shores and scattered in deep water of the river channel. Four dump scows are used, each 75x20x5 ft. 8 in. and holding 106 cu.yd. each.

At Five Mile Bar (450 miles below Pittsburgh) the material consisted of boulders, cemented gravel, gravel and sand, and is extremely hard material to excavate. Dynamite was used over a portion of the area dredged, to break up the cemented gravel. The delays incident to necessary repairs to the machinery of the dredges, caused by the severe work to which they were subjected, combined with the low stages of the river, made the progress of the improvement very slow and the cost per cu.yd. of excavation rather large.

On the Pacific coast the records of three dredges are given.

French Railway Earnings for the first half of 1912 were more than for the corresponding period of 1911; the state railways earned a little more than 1%, the Northern 1⅝%, the Eastern 2%, the Southern 4%, the Paris, Lyons & Mediterranean (nearly 6000 miles), 5½%, the Western 1%, and the Orleans 6¼%.—"Railway Age-Gazette," Aug. 30, 1912.

TABLE SHOWING OPERATIONS OF DREDGING PLANTS OWNED AND OPERATED BY THE ENGINEER DEPARTMENT AT LARGE, U. S. ARMY FOR THE FISCAL YEAR ENDING JUNE 30, 1911

CLASS C.—BUCKET AND DIPPER DREDGES.

Dredge	When Built	Contract Cost and Outfit	Dimensions of Hull Length Beam Depth	Draft Forward	Draft Aft	Bucket	Capacity	Length of Boom	Dimensions of Main Hoisting Engine Cylinders		Boilers		Diameter	Length		Steam Pressure	Crew	Dredging Capacity per Hour	ocation of Dredging	Character of Dredged Material		Material Dredged During Year 1910-1911	Total Cost of Dredging	Total Cost per Cubic Yard
	Year	Dollars	Feet	Feet	Inches	Type	C.YD		Inches	No	Type		in.	ft.	h.p.	lbs.	men	c.yd.				Cu. Yds.	Dollars	Cents
Addison	1880	14,000	75x30x7	3'-2"	2'-6"	Dipper	1½	31	9x18	1	Locomotive		54	15½	60	90	6	24	Kanawha R.	Gravel, Sand, Stone	*	15,306	3,721	24.3
Alabama	1891	22,300	80x38x6	3-6	3-6	Chain Buckets	5-c.f.	None	10x14	1	Marine		60	17	40	90	7	213	Tennessee R. Ala.	Soft Mud, Gravel	*	137,088	6,888	5.0
Albany	1908	11,731	70x30x5	1-6	1-6	Orange Peel	1	60	8½x10	1	Upright		50	10	30	100	7	50	Flint R. Ga.	Blasted Rock	*	18,531	4,433	23.9
Attalla	1902	17,000	75x26x6	3-9	3-9	Teeth Dipper	1¼	28	8¼x10	1	Internal		78	12½	60	160	7	60	Coosa R. Ga.-Ala.	Sand, Gravel, Blasted Rock	*	12,000	4,866	40.5
Autauga	1902	13,440	75x26x6	4-0	3-5	Teeth Dipper	1½	30	8x10	1	Locomotive		48	14½	45	100	9	120	Alabama R. Ala.	Sand, Gravel, Marl	*	25,464	2,895	11.4
Carrollton	1901	22,272	80x30x7	4-6	3-0	Dipper	2½	40	10x14	1	Tubular		54	16	70	110	9	90	Kentucky R. Ry.	Sand, Gravel, Mud	†	37,815	7,139	18.9
Frankfort	1908	10,193	72x19x5	3-6	2-6	Dipper	¾	27	8x10	1	Firebox Tubular		50	15	40	125	9	50	Kentucky R. Ry.	Mud, Leaves, Sand, Stone	*	36,118	4,736	13.1
Green River	1896	4,094	112x31x4	2-9	2-9	Dipper	1	50	8x12	1	Locomotive		48	14	61	150	8	50	Green-Barren Rs.Ky.	Loose Gravel	†	292,800	14,617	5.0
Kentucky	1900	34,300	100x34x7	4-0	3-5	Dipper	1¼	45	12x16	1	Locomotive		66	20	100	100	10	175	Tennessee R. Tenn.	Soft, Hard Pan, Rock	†	40,465	5,996	14.8
Kwasind	1899	11,000	80x28x7	3-3	3-0	Dipper	2-4	45	9x10	1	Locomotive		42	15	40	120	8	87	Tennessee R. Tenn.	Stone Sand, Clay	†	13,500	12,000	90.8
Sapelo	1894	12,000	85x31x5	3-0	3-0	Dipper	1½	38	9x10	1	Locomotive		48	8	45	100	10	40	Oconee R. Ga.	Gravel, Rock	†	160,300	22,687	14.0
Tennessee	1910	37,513	100x34x7	4-4	3-2	Orange Peel	¾	56	7x10	1	Vertical Tube		66	20	100	125	10	150	Tennessee R. Ala.		*	58,335	7,900	13.5
Upatoi	1901	15,718	85x30x6	3-9	3-9	Dipper	1½–2	45	10x14	1	Locomotive		40	17	135	100	10	125	Chattahoochee R.Ga	Sand, Gravel, Rock				
Wolf	1897	8,000	80x28x5	3-6	1-8	Dipper	2	35	10½x12	2	Locomotive		54	18							†	12,100	2,227	18.4
No. 1 D.B.	1908	8,800	55x27x6	2-6	2-8	Clamshell	1	40	9½x10	1	Locomotive		44	16	40	100	6	40	Wolf R. Tenn.	Sand	†	50,575	8,589	17.0
Dredge No. 1	1903	18,950	80x30x7	2-6	3-11	Dipper	1	40	9½x10	1	Locomotive		44	16	40	100	6	40	Guadalupe R. Tex.	Sand, Gravel	†	14,470	1,013	7.0
No. 19	1906	4,500	76x25x7	2-8	2-4	Clamshell	1½	45	8x12	1	Locomotive		53	8½	50	100	15	60	Cumberland R.Tenn.	Sand, Gravel	†	14,470	1,013	7.0
							1	45	8¼x10	1	Fire Tubular		42	12½	40	100	5	75	Tombigbee R. Ala.	Mud, Rock	†	1,700	400	24.0
Totals		$265,811											43	8	30	125	5	40				967,177	$114,275	11.8
Ajax	1876	11,300	73x26x6	3-5	1-7	Dipper	1½	30	8x18	1	Upright Tubular		54	10	40	120	8	40	Ill. & Miss. Canal	Clay, Mud, Rock	*	35,987	6,864	19.1
Algoma	1872	29,500	79x30x7	5-6	3-2	Dipper	2½	Mast	12x14	1	Locomotive		52	14½	40	90	8	105	L. Michigan Harbors	Sand, Mud, Clay, Stone	*	221,960	21,661	9.7
Apache	1895	15,255	80x30x8	3-8	2-6	Dipper	2½	34	10x12	1	Fire Box		54	17½	75	90	6	40	U. Mississippi R.	Blasted Rock	*	7,893	3,900	49.2
Appleton	1876	13,000	90x32x7	3-8	2-0	Scoop Dipper	2¼	39	12x26	1	Locomotive		54	13½	86	90	6	70	Lower Fox R.	Clay, Mud, Sand Rock	*	74,055	4,953	6.7
Farquhar Col	1869	15,500	76x24x6	5-0	5-0	Dipper	2	40	10½x12	1	Marine		60	10	...	80	8	65	Grand R.	Sand, Clay, Gravel, Shale	†	45,171	7,253	16.1
Frontenac	1891	14,650	76x26x7	3-0	3-0	Dipper	1½	26	8½x10	1	Locomotive		48	15	53	100	8	50	L. Ontario Harbors	Mud, Sand, Silt, Gravel	†	48,810	7,423	15.2
Maumee	1894	30,000	100x36x11	7-8	2-10	Dipper	3½	42	14x20	2	Locomotive		56	19	100	70	13	175	Lake Erie Harbors	Mud, Bowlders	*	72,680	23,546	32.4
Omro	1878	5,500	100x30x6	1-8	2-1	Grapple	2¼	60	8x12	1	Scotch Marine		84	11	85	110	5	80	Upper Fox R.	Clay, Mud, Sand	*	94,820	3,436	3.6
Oskosh	1906	39,529	75x31x6	4-0	4-0	Chain Bucket	5-c.f.	None	9x12	1	Scotch Marine		108	10	140	125	9	200	Upper Fox R.	Clay, Sand, Muck	*	135,775	8,146	6.0
Ottertail	1882	12,600	75x24x6	2-10	1-6	Sliding Bottom	1½	28	8x16	1	Locomotive		42	16	40	90	10	60	Red R. of the North	Tenacious Clay	*	42,100	6,422	15.3
Phoenix	1885	19,525	80x30x8	3-7	2-6	Dipper	2½	34	12x18	1	Fire Box		60	15	75	125	6	70	Ill. & Miss. Canal	Rock, Gravel, Clay	*	41,420	7,698	18.6
Vulcan	1883	19,450	80x30x8	4-0	3-2	Dipper	2½	34	12x18	1	Fire Box		60	17	75	106	6	100	U. Mississippi R.	Rock	†	21,610	8,111	37.5
Dredge No. 2	1882	15,500	80x30x7	4-4	2-2	Bottom Dump	1¼	34	12x14	1	Locomotive		54	19	125	90	5	100	Ill. & Miss. Rs.	Sand, Blue Clay	†	97,746	11,301	11.5
																						940,027	$120,714	12.9
Totals		$241,309																						
Ajax	1884	16,500	82x33x10	5-8	5-2	Clam Shell	5	48	18x24	1	Locomotive		84	19	125	80	11	166	Cape Fear R. N.C.	Sand, Mud, Clay, Stumps	*	542,027	28,476	5.3
Cheraw	1906	45,500	150x29x8	5-6	6-0	Dipper	1¾	49	16½x18	2	Return Tubular		72	18	150	90	12	90	Waccamaw R. S.C.	Mud, Sand, Stumps	*	98,122	12,083	12.3
Hercules	1907	64,646	100x38x11	5-0	7-0	Clam Shell	7	55	18x24	1	Locomotive		84	23	160	90	12	160	Cape Fear R. N.C.	Sand, Mud, Clay, Stumps	*	566,631	34,117	6.0
Scuppernong	1904	10,300	78x32x7	2-10	2-10	Clam Shell	2½	43	7x12	1	Locomotive		62	20	100	75	11	36	Neuse, etc. Rs. N.C.	Mud Hard Pan, Rock	*	81,628	13,098	15.8
Derrick A	1907	6,000	80x28x4	1-9	1-11	Orange Peel	1¼	45	10x13	1	Upright Tubular		48	8½	...	100	10	25	Congaree R. S.C.	Sand	*	3,180	1,251	39.3
Bank Derrick No. 1	1910	4,487	33x8-car	..	..	Grab	1	45	8x12	1	Plain Flue		46	8½	50	125	3	40	Waccamaw R. N.C.-S.C.	Sand, Mud, Stumps	*	27,004	3,355	12.4
Bank Derrick No. 2	1910	2,787	33x8-car	..	..	Orange Peel	¾	45	8¼x10	1	Plain Flue		40	9	25	100	3	35	Waccamaw R. SC..	Sand, Mud, Stumps	*	23,546	3,022	12.8
																						1,342,138	$ 95,402	7.1
Totals		$150,120																						
Cascade	1906	6,056	60x30x5	2-0	2-0	Orange Peel	1	52	10x12	1	Vertical		53	8½	50	90	8	59	Columbia R. Ore.	Silt	*	34,160	5,309	15.5
Champoeg	1904	20,200	80x30x5	2-10	2-7	Dipper	1	40	8x12	1	Locomotive		42	15½	40	90	10	69	Willamette R. Ore.	Gravel	*	43,433	10,383	24.0
Cowlitz	1895	4,750	78x34x6	2-2	2-3	Clam Shell	1½	60	10x12	1	Return Tubular		84	12	80	90	10	75	Clatskanie R. Ore.	Sand, Gravel, Clay	*	57,186	6,483	11.2
																						134,779	$22,175	16.5
Totals		$31,006																						
Casey	1907	15,132	86x28x7	2-6	2-6	Clam Shell	2	42	11x18	1	Locomotive		60	...	80	100	5	200	Ohio R.	Mud, Cinders	*	68,950	5,093	7.4
Louisville	1886	25,000	67x28x6	2-4	2-4	Dipper	2	30	12x14	1	Locomotive		54	...	60	100	6	90	Ohio R.	Mud, Cinders, Rock	*	42,375	5,502	13.0
Malta	1888	17,000	70x31x7	3-6	3-0	Chain Bucket	3-c.f.	None	10x16	1	Locomotive		48	17	55	90	9	120	Muskingum R. O.	Sand, Gravel, Mud, Rock	*	91,763	13,913	15.2
Ohio	1873	35,000	110x32x7	2-11	2-11	Dipper	2⅞	24	12x15	1	Roberts W.T.		..	...	150	120	14	250	Ohio R.	Gravel, Sand, Bowlders	*	109,579	22,102	20.2
Oswego	1883	35,000	92x32x6	3-3	3-3	Dipper	2⅞	24	12x15	1	Roberts W.T.		..	...	120	120	12	250	Ohio R.	Gravel, Sand, Bowlders	*	122,967	20,726	16.7
																						435,634	$67,336	15.5
Totals		$127,132																						
Hellgate	1869	25,0001	10x35x12	6-0	6-0	Clam Shell	6	50	18½x24	1	Marine Leg		96	14	60	70	11	100	Delaware R.	Mud, Ledge Rock	†	11,866	$16,033	135.0
Dredge No. 1	1903	17,565	85x32x6	4-6	3-6	Dipper	2½	40	11x14	2	Locomotive		54	18							†	84,850	28,822	33.9
											Vertical		30	6	70	110	9	100	Monongahela R. Pa.					
Dredge No. 2	1905	21,600	87x30x5	3-2	2-6	Dipper	1¼	35	10x14	2	Locomotive		54	18							†	115,614	26,152	22.6
											Vertical		36	7	75	100	9	67	Monongahela R. Pa.					
																						212,330	$71,007	27.4
																						4,032,085	$490,909	12.2
Totals		$64,165																						
Grand Totals		$879,543																						

* Includes repairs. † Operating cost only.

The Construction and Operation of a Model Municipal Comfort Station

By Burt A. Heinly*

The city of Los Angeles, Calif., has recently constructed and placed in operation a model public-comfort station, a description of which, it is believed, will be of interest for the reason that it embodies a number of new features and has been built, with the exception of the plumbing, wiring, tiling and marble work, entirely by city day labor at a cost of $3573 less than the lowest bid submitted by contractors. Ready for the public, supplies and furniture excepted, the total cost was $10,779.

The general appearance and the entire arrangement of the building have been favorably commented on by both building experts and the visiting public, and the general opinion is that the station compares favorably with the finest in the country. From data secured from all parts of the United States, the investigation shows that this station has been built for about 60% of the cost of buildings of a similar character elsewhere.

When the present park commission took office in 1910 they found Central Square, which is nearly in the heart of the retail shopping district, in a dilapidated condition. In the center of the square was a wooden bandstand, the basement of which served as a comfort station. This station was a public nuisance, so much so that one of the first acts of the new commission was to tear out the fixtures and disinfect the building with quick lime in order to protect the public health.

The city council appropriated $10,000 for a new building. A local firm of architects was employed to draw plans for the present station shown in Fig. 1. Bids were called for, but all were rejected as being in excess of the appropriation.

A year later, bids were again called for. The lowest submitted was $14,352, the highest $19,110, whereupon the commission resolved to do the work by force account and placed the undertaking in the hands of Frank Shearer, Park Superintendent, who had submitted as his estimate the sum of $10,800. The city building inspector's office at first refused permission to the commission for the undertaking, claiming that its own estimate of $15,239 was the minimum amount for which the station could be constructed, and the work could not be started until this full amount had been appropriated. The station was a necessity and with the $10,000 in its treasury, the commission started the project simply as "park work."

The location of the station is on Hill St., midway between Fifth and Sixth Sts.

*City Water Dept., 636 South Hill St., Los Angeles, Calif.

The length overall, including the two stairways is 75 ft., and the breadth, including the work room of the park force is 30 ft. Entrance is made by two stairways surmounted by ornamental iron railings. These stairways are placed at each end of the station, one for men and one for women, and open directly from the street sidewalk.

The station begins 4 ft. inside the curb line, extends under the sidewalk and 21 ft. into the park, where with the exception of the stairways, it is covered with 2 ft. of soil. From floor to ceiling, the building has a height of 8 ft. 6 in. The outside walls are of reinforced concrete 15 in. thick. The roof is of the same material with a thickness of 24 in. beneath the sidewalk, and under the park a thickness of 12¼ in., sloping to 7¼ in. to provide drainage. Here the concrete is covered with two layers of waterproof felt treated with two coats of heavy coal tar.

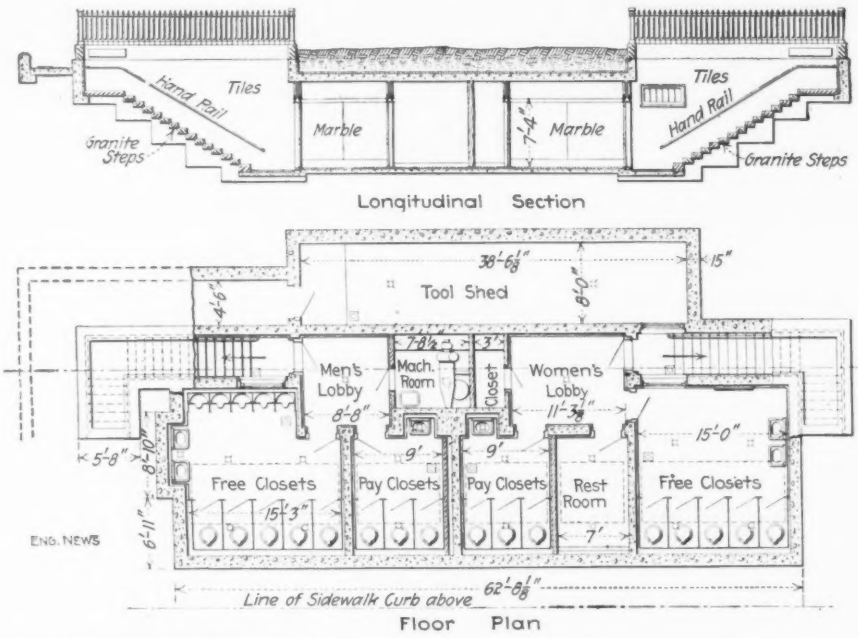


FIG. 1. PLAN AND SECTION OF A MODEL PUBLIC COMFORT STATION, LOS ANGELES, CALIF.

The station has been in service one year, during which time the lawn has been irrigated daily, but no leakage is apparent. The floor is of concrete 6½ in. thick, covered with 2-in. hexagon tiles. Three main partitions, as shown in Fig. 1, are 11-, 12- and 22-in. concrete, respectively, and support the roof. Other partitions are of tile.

The light is admitted through prismatic glass set in the sidewalk, and in the tool room by windows in the women's stairway entrance.

At the rear of the toilets there is a 7-in. air space between the concrete wall and the marble wainscoting. Air currents passing from the two entrances are sucked through registers into this space by a small motor-driven fan and discharged into the park through an ornamental vent with grating. In addition, each toilet is directly connected with a 4-in. metal vent pipe that, on the outside, is carried to a height of 20 ft. and screened from view by foliage. Mott plumbing and fixtures have been used throughout.

The interior work is of the finest Italian marble in panels 7 ft. 4 in. high with marble baseboards. The contract called for Alaskan marble, which the contractor was not able to procure within the time limit of his contract. Rather than pay the penalty he found it cheaper to substitute Italian marble at a stated loss of $300.

In the women's apartment, the stairway opens into a lobby 9 ft. by 11 ft., containing the attendant's desk, chair, cash register, a linen closet 3 ft. by 7 ft., and a woman's pay sanitary cabinet with receptacle. Opening from the lobby is the woman's rest-room and free compartment. The former is 7 ft. by 11 ft., and is equipped with a couch, dresser, mirror, combs, brushes, wicker chairs and a medicine cabinet containing first aids to the injured for street accidents, etc. The free compartment is 15 ft. by 16 ft., and is equipped with 5 toilets and 2 wash basins. The pay station also opening from the lobby is 9 ft. by 11 ft. and is equipped with 3 toilets and 1 basin.

The men's apartment is shut off from the women's by a concrete wall and consists of four rooms: the lobby, 8 ft. 8 in. by 9 ft., with desk, chair and cash register; the free room, 15 ft. 3 in. by 15 ft. 11 in., equipped with 5 toilets, 5 urinals and 2 basins; a pay station, 8 ft. 8 in. by 9 ft., with 3 toilets and 1 basin; and a store room 7 ft. by 8 ft., containing linen supplies, fan, motor, slop basin, electric switches and automatic hot-water heater.

The tool and work room for park em-

ployees is reached by an incline in order that mowers and barrows may be run in and out without difficulty. In this compartment, 38 ft. 6 in. by 8 ft., the fixtures are elaborate and up to date. There are 5 individual lockers for changes of clothing, lunches, etc., for the workmen; 5 tool lockers, the tools being numbered and each man being made responsible for his own kit, a work bench and a complete pipe-fitting outfit. In addition this room provides accommodation for the pump and motor for the park's electrical fountain, power and gas meters, etc.

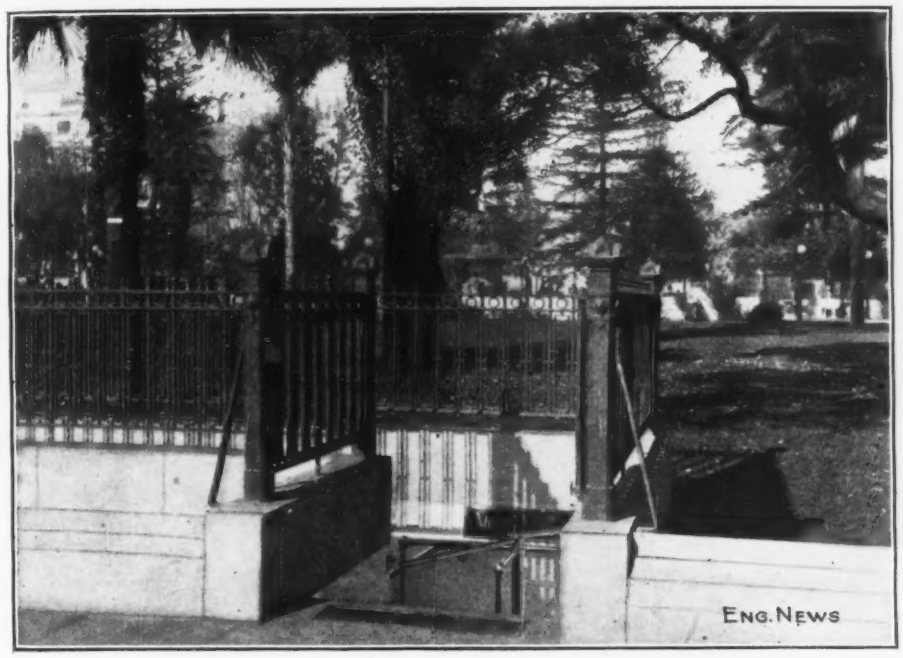


FIG. 2. ENTRANCE TO WOMEN'S APARTMENT, LOS ANGELES MODEL PUBLIC COMFORT STATION

Only one change was made in the specifications. This was in the substitution of concrete for the more costly granite stairways, making a difference in cost of about $50. Otherwise the plans as submitted to the contractors were rigidly adhered to.

The gang employed averaged 12 men working 8 hours at $2.25 to $2.75 per day with a foreman at $125 per month. The excavated material was carted away, free of charge, by a contractor who desired it for a fill.

The itemized costs were as follows:

Marble, tile, mirrors, etc., in place	$3,450
Electric wiring complete	167
Plumbing, sewer and gas complete	2,550
Reinforcing steel	264
Plastering and metal work in toilets	150
Hardware	93
Sidewalk prismatic lights	450
Frames, sashes, doors and glass	397
Roofing material	35
Ventilation (fan, motor, galvanized iron work, registers, etc.)	230
Ornamental iron railing in place	670
Cement	520
Concrete work, including forms	375
Tile partitions	24
Excavation	500
Painting	50
Sand and gravel	199
Crushed rock	126
Hot-water heater	68
Building permit	11
Supervision	450
Total	$10,779

It should be noted that Mr. Shearer has not allowed for his own time and his general supervision of the work, which was considerable, as he not only kept in the closest touch with the construction but he personally secured bids on all the materials purchased.

The economic operation of the station is as follows: In the free compartments, the soap and linen are replenished as often as necessary; in the pay compartments for which a charge of 5c. is made, there are individual towels, soap and hot water. No charge is made for the women's rest room.

The station is open from 7 o'clock in the morning to 9 o'clock at night; there are two sets of attendants who work 8 hours each, and put in 1 hour before opening and after closing in the cleaning of fixtures. In addition there is a scrubber who comes on after 9 p.m. and cleans the floors, stairways, etc.

FIG. 3. CORNER OF MEN'S LAVATORY, MODEL PUBLIC COMFORT STATION

The attendants are negroes supplied through the Civil Service Commission. The salary is $65 per month. Tipping is rigidly prohibited. The women attendants are graduate nurses and are well qualified in every way to act in emergency cases of accident or illness.

The rest room proves a positive boon for women taken ill, who may rest there until sufficiently recovered to go or be taken to their homes. It serves a want such as the police emergency hospital and a clanging ambulance cannot fill.

How is the station patronized? Whereas the old comfort station was shunned by the class it was sought to serve, the new station is patronized by all classes, and from the nature of the surroundings and the presence of attendants all classes are quiet and orderly. In the compartments for each sex, the number passing through the gates averages one per minute throughout the day. The pay rooms have so far produced a revenue that averages about $100 per month.

Considering the congested nature of city streets, Mr. Shearer has reported to the park commission that these stations should be constructed under street intersections with tunnel crossways. These tunnels with passages leading off to the comfort stations would also provide a safe means for foot passengers to cross the streets at congested points.

A Motor Street Sprinkler has been recently put into use in St. Louis, Mo. It consists of a 1400-gal. water tank mounted on a 6½-ton motor-truck chassis. A pump with a capacity of 400 gal. per minute is driven through suitable gearing from the main engine of the truck and delivers the water with a pressure of 10 or 12 lbs. at the sprinkling nozzle. The pump is geared for 400 r.p.m. with the truck running at a speed of 6 miles per hour. It is estimated that this gives a water distribution of one gallon per 45 sq. ft. The water is thrown out through the nozzles to a considerable distance on either side of the car. It is claimed that this machine has displaced four horse-drawn water wagons of the usual type.

The sprinkling nozzles are at the front of the machine in plain view of the driver. Control of the sprinkler is effected by means of two levers, one of which operates the jaw-clutch connecting the pump to the engine and the other controls the gate valves regulating the flow from the two nozzles, either independently or together.

Recognition of the fact that to get the full advantage of motor driven apparatus every effort must be made to keep it in actual motion as much of the time as possible is evidenced by the provision of a special device for filling the tanks. An automatic spring check valve is supplied on the hydrant from which the tank is filled which automatically closes when the tank is full, so that no attention is required from the operator other than disconnecting the hose from the hydrant. A float gage is provided which permits the operator to judge the height of water in the tank. The motor sprinkler was built by the International Motor Co., Broadway and 57th St., New York City.

A Shoveling Machine for Loading and Handling Loose Material

One of the desirable applications of labor-saving machinery is in the loading of loose material into cars or wagons for transportation. The field for machines of this class includes the handling of excavated material at quarries or engineering construction works, the handling of ore, coal and broken stone from stock piles, the loading of coal and ore in mines, and a variety of miscellaneous uses. Such machines must be portable. Machines of this class described in our issues of Feb. 29 and June 20, 1911, are of the excavator class, consisting in each case of an endless chain of buckets. In the machine described below, the action is entirely different, there being two distinct operations for loading and conveying. In this new loading machine, which is termed by its builders a "shoveling machine," the loading element has a shoveling or thrusting action which is not obtained in the conveyor buckets, and it handles the materials in larger quantities than the individual buckets of the latter class of machine. A general view of the "shoveler" is given in the accompanying cut.

The shovel at the head of the machine consists of two parts. The front part or shovel proper *A* is supported by a crankshaft *B*, about 15 in. back of its front edge. The sides of this front section extend backward to a cross shaft having rollers on each end, the rollers running in cam grooves. The rear or inner shovel *C* is mounted on this cross shaft; it fits between the sides of the front shovel and has ears projecting upward with cam rollers to engage secondary cam grooves for tilting the rear shovel. The crank *D* rotates constantly in one direction, being driven from shaft *E* by a sprocket chain passing over sprocket wheels on the shafts and concealed within a sheet-iron casing. The shovel is thrust forward under the material, and as the crank moves farther it lifts the shovel through the material until when the bottom of the digging shovel reaches its greatest inclination the material slides back into the inner or rear shovel. As the crank continues to rotate, the rear shovel is forced backward and up the inclined cam ways; the cam rollers on ears engage the secondary cams, and this rear section is then rotated on the cross shaft until finally at the end of stroke the material is discharged upon the conveyor *F*. The shoveling action is continuous and automatic.

The front part of the machine is made to swing laterally so as to reach all material within 10 ft. on each side of the track. The pivoting point is approximately over the front axle of the supporting truck. This lateral movement is controlled by a handwheel and friction gears. In order to feed the machine forward as the material is cleaned up, it is made self-propelling. It is moved forward or backward by means of gearing with friction clutches, the clutches being controlled by handwheels on the mining machines and by hydraulic transmission on the tunnel machines. From the driving shaft sprocket chains lead to one of the axles.

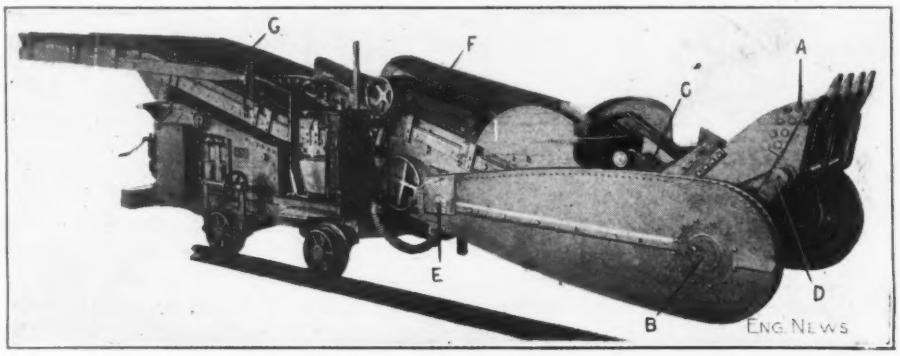
Behind the shoveling device and carried on the same swinging frame is a belt conveyor *F* which receives the material from the shovel and discharges it upon a second belt conveyor *G* mounted on the main frame. This second conveyor is also mounted on a pivot, so as to swing to each side for loading cars on curves or on adjacent tracks. All the parts are carried on one frame, and no struts or outer supports of any kind are required. This makes the machine very flexible, easy to handle, and easy to move from one place to another. The shovel has a thrust of about 3000 lb. and can lift 1200 lb. It will handle material as large as will get into the shovel.

The latest machines designed for tunnel work have a platform mounted on the front swinging frame or jib, with a seat for the operator. This is the machine shown in the cut. All controls are carried to this platform and the runner can handle the machine as easily as a motorman handles a street car; his elevated position enables him to see just what the shovel has in front of it, and permits him to operate it with greatest efficiency. One of these machines has been built for use in the tunnel for the Catskill aqueduct and will be put at work as soon as the contractors are ready to use it.

A small size of machine designed particularly for mines and underground working has a maximum height of 38 in., so that it can be operated readily in workings having low head room. It weighs 3 to 3½ tons and can average 10 to 20 tons per hour. A larger machine, for work in mines or tunnels with a height of 6 ft. or more, is in use for loading rock in the tunnel for a hydro-electric plant at Tallulah Falls, Ga., and also for loading coal from a 6½ ft. seam in the mine of the U. S. Coal & Oil Co., at Holden, W. Va. This machine is 25 ft. long over all, 4 ft. 9 in. wide, and 4 ft. 9 in. high, with a weight of about 6 tons for handling coal or 7 tons for rock. It has a wheelbase of 41 in. on a track of 3 ft. 6 in. gage, and the shovel has a width of 34 in. It can handle 2875 lb. of coal or 0.80 yd. of rock per minute, averaging 24 to 26 tons of coal or 10 to 12 yd. of rock per hour. This time includes the shifting of cars and machine. It requires about 12 hp. for operating. The accompanying table is a record of four days' test run at the mine mentioned above.

The machines may be operated by electric motors, or by steam, gasoline or compressed-air engines. They may be mounted on flanged or flat wheels, one axle being driven by a sprocket chain in either case. They are built with a view to the rough usage they are likely to receive in regular work. The gears are of steel with cut teeth (except that spiral gears are of bronze), and the driving chains are of steel with bronze bushings. The gears and chains are housed in oil-tight casings as far as possible. Ball bearings are used to take end thrusts, and roller bearings are used on the conveyor shafts. It is stated that the machines can be used for light excavation in grading or stripping, as well as for loading. A modification of the machine is made with a long elevating conveyor, this being adapted specially for loading to or from stock piles of ore, coke, coal, stone, etc. For loading coke into cars, the head of the conveyor may be fitted with a screen, so that the dust or breeze will be removed before the coke is delivered to the car. In this design, the whole machine revolves through an entire circle, the main frame being mounted upon a turntable on the truck, which has a wheelbase of 6 ft. The length is 17½ ft. from the pivot to the head of the shovel and 20½ ft. to the head of the rear conveyor, which can be raised to an elevation of 16 ft. above the ground.

The machines described are built by the Myers-Whaley Co., Empire Bldg.,



A Loading Machine of the Shoveling Type, with Shovel Delivering to Belt Conveyors
(Myers-Whaley Co., Knoxville, Tenn., builders.)

Knoxville, Tenn., and we are indebted to the company for photographs and information concerning them.

RESULTS OF A TEST OF A SHOVELING MACHINE FOR LOADING COAL IN A MINE

Date 1912	No. of places loaded out	Time consumed: Actual Loading		Shifting Cars		Moving machine	Tons loaded	No. of men
		hr.	min.	hr.	min.	min.		
May 8	5	4	47	0	54	23	147	4
May 9	4	3	55	0	49	9	120	4
May 10	4	3	56	0	40	18	114	4
May 11	4	3	24	0	46	6	102	4
Total	...	16	02	3	09	56	483	...

Total time loading, shifting and moving..20 hr. 7min.
Total coal loaded.....483 tons
Tons loaded per hour.....24.1 tons
This does not take into account any delays caused by pulling down coal or waiting on shot firing.

Successful Use of Sawmill Refuse in Gas Producers

The successful use of sawmill refuse as fuel in gas producers was described by C. E. Snypp before the Louisiana Engineering Society, May 13, 1912, in a paper reprinted in a recent number of of the *Journal* of the Association of Engineering Societies. The producer plant was installed to burn Pittsburgh bituminous coal and to furnish a gas of about 125 B.t.u. per cu.ft. to the engines. The producer was a pressure type, rated at 840 hp., and consisted of a combination of three units, each having a producer shell 8 ft. in diameter by 12 ft. high with steam-jacketed top. There was one wet scrubber, one dry scrubber, one pressure fan, one gas holder, and one motor-driven mechanical tar extractor.

With the first coal used, Pittsburgh bituminous, the requirements as far as richness of gas was concerned were met, but the plant went out of commission at regular intervals in consequence of tar congestion. The intervals came closer and closer together the longer the plant was operated, on account of the greater and greater accumulation of peculiar tar. The tar was too heavy for the centrifugal extractor, and breakdowns of this machine were frequent. This led to trying other bituminous coals. After four years of continuous service on various coals in spite of the attempt at selection the whole system of pipes and engines was becoming congested with tar. It was found expensive to remove this tar from the engine cylinder rings. In fact, many rings had to be cut from the grooves with a cold chisel.

Alabama coals were selected particularly for high fixed carbon and low-volatile matter. There was some better satisfaction then because of reduced quantity of tar, with a gas as rich as before. This coal had to be abandoned after a while on account of the irregular quality, particularly as to volatile matter and ash. Not only was the ash content high, but it had the peculiar property of fusing into a solid clinker, which was almost impossible to penetrate with poke bars, and it could not be broken into pieces of a size to be readily removed. The act of fusing cut off the air from the fuel beds, produced a lean gas, and finally put the producer out of business.

Anthracite was tried, but the gas was too lean, being about 100 B.t.u., and the fuel was too expensive. Coke and coke breeze was substituted. This furnished a gas of about 110 B.t.u., but trouble was experienced with producers filling up with ash and clinker, resulting in cavities, which could not be filled by poking. Often the quality of the gas fell as low as 80 B.t.u., but it was noticed that when the gas became so lean the thermal value could be raised by feeding in barrel staves.

On that account sawmill refuse was tried and it was found that the plant could be operated continuously on about 130 to 135 B.t.u. gas with great reliability. After about a month's use of refuse the tar troubles began to disappear, and now after two years it is a rare occurrence to have an inlet or an exhaust valve stick on account of tar or carbon deposits. The dry scrubber has been discarded and one week the plant was operated without a tar extractor at all. The refuse is known as "cypress hog." It consists of about 50% of sawdust and 50% of chips, and it runs from 30 to 55% water, but this moisture seems to be necessary for the best working conditions.

The changes necessary to fire sawmill refuse were merely the removing of the coal dump hoppers and substituting a hollow cylinder about 10 ft. high, slightly tapered and made larger at the bottom, fitted with a slide gate at both top and bottom so that sawmill refuse could be locked into the producer through the tubes without admitting excess air.

It was not necessary to have an underlying bed of cinders or ash to cover the blast pipe. The fuel could be dumped in on the water seal and fire started either on top or through the side poke holes. Aside from these conditions, the beds seemed to be subject to all conditions prevalent in the firing of coal. A brittle clinker was formed, easily removed with the fine ash. The percentage of ash was so small that a producer could be operated about three weeks before removing any ash. Cavities and chimneys would form in the bed, and eternal vigilance and poking were necessary to produce a uniform quality of gas. To lessen the labor of poking it was thought good practice to feed occasionally, say once a day or whenever the quality of the gas fluctuated, one or two charges of blocks ranging from stove lengths to 15 in. in diameter. These blocks found their way into the cavities and stopped up the chimneys so that the producer responded instantly.

We also experimented with "pine hog" and found it a more efficient fuel than the cypress, a gas of 161 B.t.u. being secured against 130 to 135 for cypress. The heating value of the two fuels showed 5540 B.t.u. per lb. for cypress and 7605 for pine, with its natural moisture.

The plant work was of such a character that the producer had to be operated 24 hours a day and sometimes on Sunday. The following table of cost has been made from the plant records:

Cost of cypress waste fuel (basis 4½ lb. per hp-hr. at 50c per ton)	0.1125c per hp-hr.
Cost of firing 4½ lb.	0.1125c
Total cost per hp-hr. for cypress waste	0.2250c
Cost of Pittsburgh bituminous coal (basis 1.5 lb. per hp-hr. at $4.10 per ton) equals	0.3075c per hp-hr.
Cost of firing 1.5 lb. of Pittsburgh bituminous coal	0.0750c
Total cost per hp-hr. for Pittsburgh bituminous coal	0.3825c
Cost of Alabama bituminous coal (basis 1.5 lb. per hp-hr. at $2.75 per ton) equals	0.2062c per hp-hr.
Cost of firing 1.5 lb. of Alabama bituminous coal	0.0750c
Total cost per hp-hr. for Alabama bituminous coal	0.2812c

An Automatic-Stop and Cab-Signal system for railway signaling, which is being brought to the attention of railway officers, is based on the closed-circuit principle, in which the track rails are utilized for the signal current and no separate contact rails or track devices are required. Adjacent to the end of each block are lengths of rails insulated from the main track circuit, but maintained as a closed circuit through relays at the end of each block. Any obstruction in the circuit of one block, such as a train, open switch, broken rail, etc., deënergizes the relay in the two adjacent blocks in front and rear, and isolates the insulated rail sections from the main track circuit. Attached to the engine is a contact brush or shoe which controls the relay in the cab, and this in turn controls a special valve in the train-line air pipe. The engineman gets a red signal in the cab at a point far enough in advance of the end of the block to give him ample time to bring his train to a stop. In fact, he can pass into the next block at slow speed without causing the automatic device to operate. This, of course, enables him to proceed under control without waiting indefinitely to ascertain how or why the track is obs ructed, while at the same time it avoids the undesirability of applying the brakes to a train proceeding under proper control.

The contact brush passing over the insulated rail sections when track circuit is interrupted (by train or other obstruction) deënergizes the relay in the cab, which in turn releases a lock lever, permitting a weight attached to the valve to drop, thus applying the air automatically and bringing the train to a stop. The movement of the valve is automatically recorded, so that it cannot be concealed by an engineman who wishes to avoid knowledge of carelessness in obeying a stop signal. In order to proceed, he must break a seal, thus releasing a lever, which enables him to restore the valve to its normal position. The device mentioned is that of the Thompson Automatic Signal Co., People's Gas Building, Chicago. No installation has been made.

Four Alternate Designs of Hollow Concrete Dams for Stony River Dam, Grant Co., W. Va.

By Edward Wegmann*

The West Virginia Pulp & Paper Co. has a large paper mill on the Potomac River at Luke, Md., opposite Piedmont, West Va. The wash water used in the manufacture of paper is obtained from the river, but its flow is at times insufficient for the requirements of the mill. The deficiency of water occurs occasionally in winter, when the springs in the mountains feeding the affluents of the river are frozen, as during droughts in midsummer. About a year ago the company decided to construct a reservoir in the watershed of the upper Potomac in order to store water for feeding the river during stages of low water. Owing to the steepness of the mountains in West Virginia, it was not easy to find a site where a reservoir of the required storage capacity could be constructed at a reasonable cost. After a thorough investigation, the place finally selected for the reservoir was on Stony River in Grant Co., West Virginia, at an elevation of about 3000 ft. above tide. At this site a dam, 1000 ft. long, with a maximum height of about 50 ft. above the foundations, would store 1,500,000,000 gal., a quantity sufficient for the needs of the paper mill.

The soil at this place is generally of an argillaceous nature, a yellow clay, mixed with very fine sand or gravel which is underlain by stiff blue clay, and some soft seams of a black material occurring in places. A great many sandstone boulders lie at or near the surface, some of them furnishing excellent building material, while others are badly decomposed. There are no quarries or sandpits within reasonable distance of the site selected for the dam and the stone and sand have to be obtained from the boulders on the surface or to be brought from a considerable distance by rail.

The preliminary estimates showed that a solid masonry dam would be too expensive. The material at the site (almost entirely clay) was not suitable for an earth dam, and the choice of type of dam was, therefore, practically limited to some kind of hollow dam of reinforced concrete.

Engineers differ somewhat as regards the advisability of building a dam of this kind. The oldest structure of this type was built in 1904 and experience has not yet shown what its life will probably be. The important questions involved are whether in the thin deck of the hollow dam the concrete will protect the reinforcing-steel bars against corrosion and, where necessary, against electrolysis.

The danger of corrosion arises principally from fluctuation in the height of the water level in the reservoir. Steel that is alternately wet and dry will soon rust. Temperature cracks in the concrete may expose the steel bars to alternate wetting and drying and thus to corrosion. If the water in the reservoir should be impure this result may be caused by chemical action.

While examples of the destruction of anchor bolts, etc., are sometimes urged by engineers against the construction of hollow dams of reinforced concrete, as usually built, there are others who have perfect faith in this type of dam.

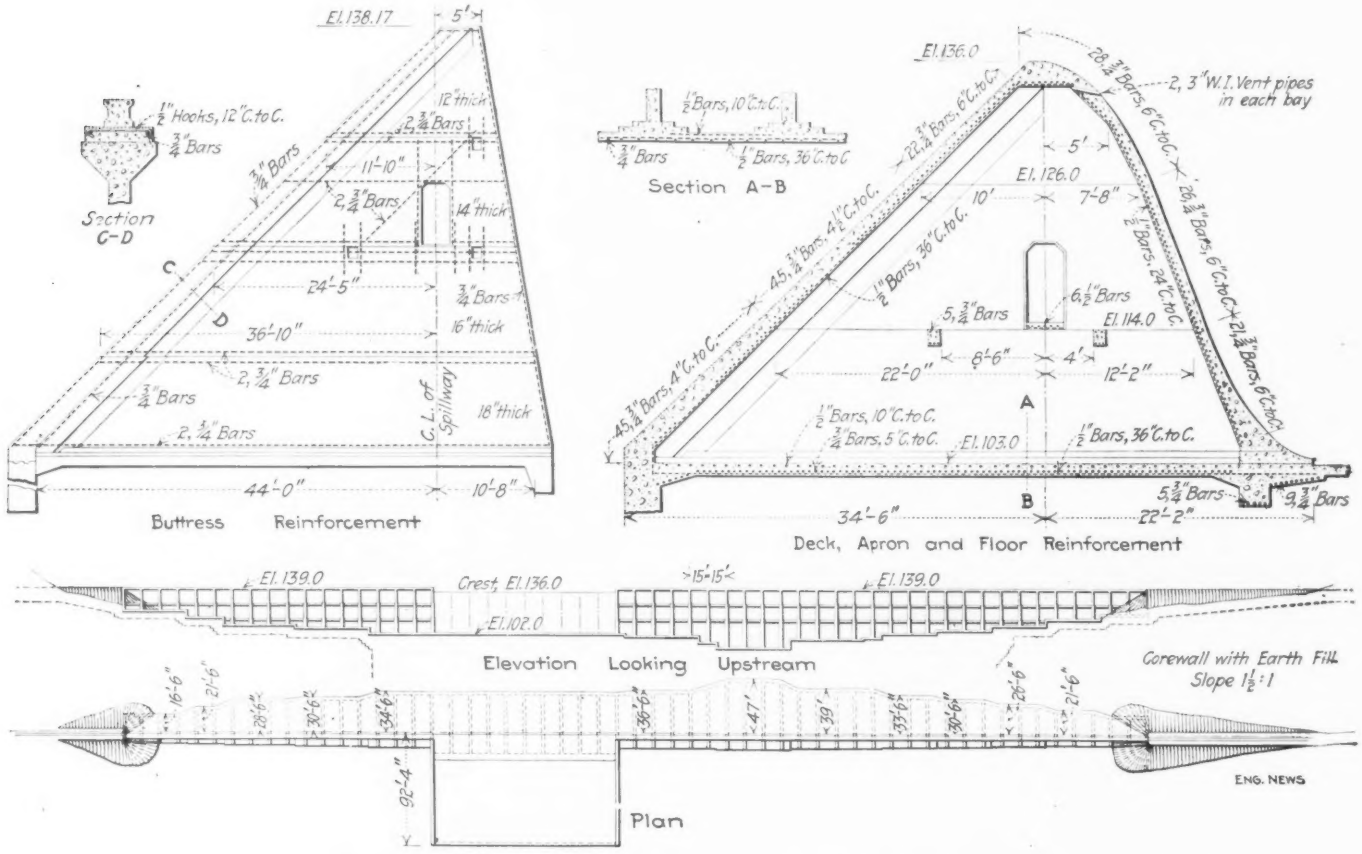


Fig. 1. Accepted Design for Stony River Dam. By the Ambursen Hydraulic Construction Co.

*Consulting Engineer, Dept. of Water Supply, Gas and Electricity, New York City.

Rusting of Steel in Concrete

W. S. Edge, Chief Engineer of the Hydraulic Properties Co. of New York, made a very thorough investigation of the corrosion of steel embedded in concrete with regard to its use in hollow concrete dams. In this connection, he examined the literature of reinforced concrete, corresponded with many engineers in active practice in building works of reinforced concrete, inspected many works of this character and made a number of experiments.

The following quotations of what different authorities say about the likelihood of steel embedded in concrete rusting are taken from Mr. Edge's reports:

Steel covered with concrete is most perfectly protected by it against corrosion. This is now a recognized fact, but it should be added that only relatively rich mix-

ture and with a plastic condition of the concrete (not earth moist) can there be attained the intimate covering and adhesion necessary to give proper protection. If a leaner and dryer mixture is employed it is necessary to wash the reinforcement with cement grout just before the deposit of the concrete to obtain the desired adhesion and security from rust.

As a proof of the existence of this property of protecting against rust, there may be cited the numerous reinforced-concrete reservoirs and sewers which have stood for decades and as yet have shown no signs of any corrosion of the reinforcement. Some examinations of 20-year-old sewers showed the steel absolutely uninjured and of the same color as when it left the rolling mill. Additional proofs are constantly being adduced by the repeated loading of structures and through the demolition of old reservoirs and floors, in none of which has ever been disclosed any corrosion of properly covered reinforcement, even when of considerable age.—"Concrete-Steel Construction," by E. Morsch; translated by E. P. Goodrich.

The rusting of iron takes place only in the presence of moisture, air and carbon diozide. In perfectly dry air, or in perfectly pure water, iron does not rust. Under the proper conditions the iron, water and carbonic acid combine to form ferrous carbonate, which at once combines with oxygen from the air to form ferric oxide, the carbonic acid being liberated to act on a fresh portion of the metal.

It is seen that only a very small amount of the carbon dioxide is necessary. If, however, the carbon dioxide or other acid following the same role, is neutralized by the presence of an alkaline substance, the foregoing reactions cannot take place. As cement is strongly alkaline, it thus furnishes an almost perfect protection against rusting.—"Cement and Concrete," by L. C. Sabin.

Observations of steel embedded in concrete which has been exposed to fire and corrosive action and experimental tests prove conclusively that 1½ to 2 in. of dense portland cement concrete made in ordinary porportions with broken stone gravel or cinders of good quality and mixed wet will effectually resist the most severe fire liable to occur in buildings, and will prevent the corrosion of steel even under extraordinary conditions. — "Concrete, Plain and Reinforced," by Taylor and Thompson.

It is undoubted that in reinforced concrete the skeleton is perfectly protected against rusting. It must be remembered, however, that for this form of construction the best materials must be used and the concrete properly and thoroughly mixed and well worked and rammed around the reinforcement so as to be free from cracks and voids.

There appears to be a chemical action between the cement and the iron forming a coating of silicate of iron on the reinforcement, which not only protects it from oxidation, but also removes any little rust that may be on it when placed in the concrete and gives a greater adhesion between the two materials. The coating protects the reinforcement against oxidation even where there is a slight passage of water through the concrete. It is not to be denied that steel and iron embedded in the concrete have in some few cases been known to have become rusted, but in such cases it has always been found that the concrete is of a porous nature and that it has not been well rammed around the iron and consequently the protective coating has in places not been formed. Even with porous concrete of furnace ashes, if this layer is obtained the metal will remain perfectly protected, though the concrete is exposed to continuous moisture.—"Reinforced Concrete," by Marsh and Dunn.

Resistance of embedded steel to corrosion.—This subject could be truthfully dismissed with the statement that the metal is so perfectly protected that rusting is not a factor in the endurance of proper reinforced construction, where none of the cost of maintenance required to prevent oxidation in a steel structure is necessary..... Somers Clark, late surveyor to St. Paul's Cathedral, being anxious as to the conditions of the great chain tie which binds the dome at its base, caused an opening to be made in the concrete in which it had been embedded for 200 years, and found the iron bright and perfect notwithstanding the fear which had naturally been felt because of the percolation of the water from the gallery over it.

J. Hanny Thompson, in the discussion at the Engineers Conference in the Institute of Civil Engineers, London, June, 1907, quoted the following important experiments:

My experience in reinforced-concrete work has been principally in connection with wharves and jetties. With regard to the rusting of the rods, I have taken up several heads of piles which have been cut off after having been subjected to heavy driving and which have been left in the water about 3 years, and on stripping the concrete the steel was found to be perfectly blue. One experiment I made was to test the effect on steel work that had been put into concrete bracings just above low water. I made two blocks of concrete about 5 ft. long and put into the concrete two rods similar to those that had been used in the construction, just as they came from the works, and two very

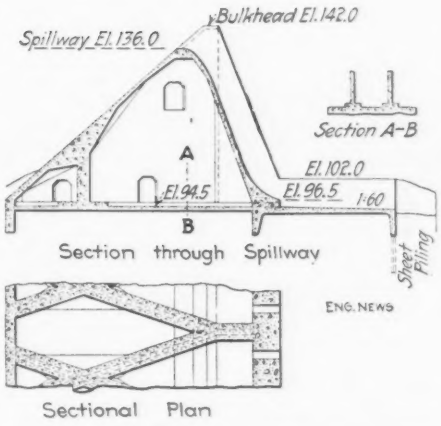


FIG. 2. RANSOM TYPE OF DAM FOR STONY RIVER. BY THE HYDRAULIC PROPERTIES CO.

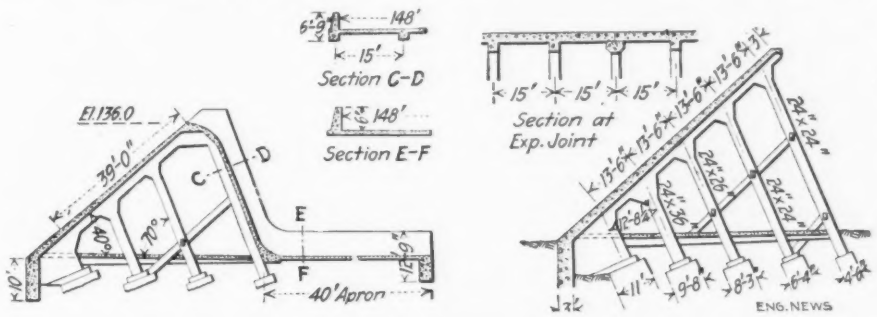


FIG. 3. MORTON TYPE OF DAM FOR STONY RIVER. WALTER S. MORTON

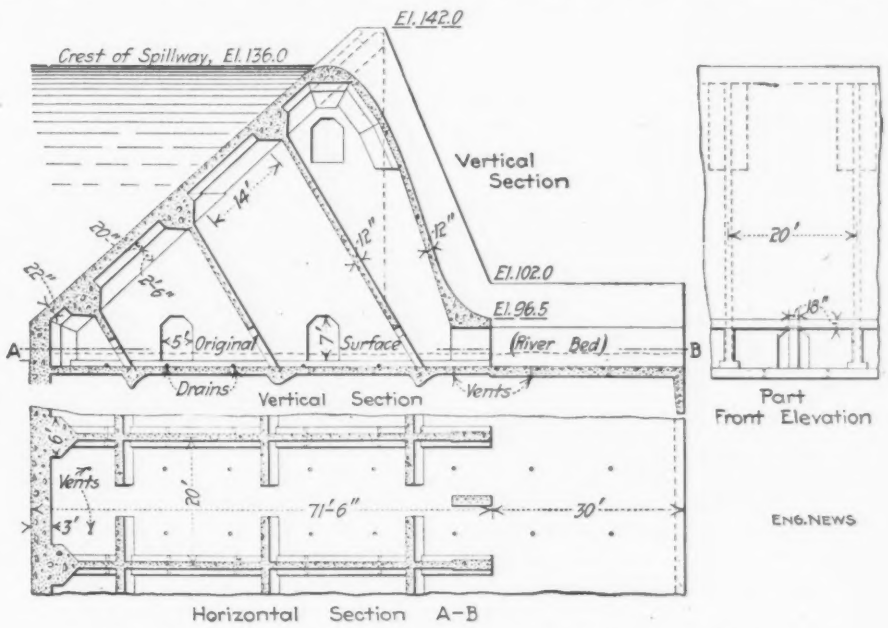


FIG. 4. EDGE TYPE OF DAM FOR STONY RIVER. BY THE HYDRAULIC PROPERTIES CO.

rusted bolts, corroded very much indeed, and very much pitted—just as bad as I could find them. One of these two blocks I had made in the dry, and after it was set, it was put under water. The other block I made just above low water level and as soon as ever the concrete was put into the mold the tide came over the block. I allowed these blocks to remain in water about three years. As to the one that was made in the dry, the new steel rods were quite blue, and from the very rusty rod I found the rust had gone entirely, leaving the pieces free from rust. The block that was made at a low water level and over which the water was allowed to flow at once, when broken I found exactly the same thing there. One very interesting point with regard to this is that I found the concrete was damp right through. There did not appear to be any honeycombing at all to the concrete, but the concrete itself was damp. But, notwithstanding that, the steel was quite free from rust in every way.—"Reinforced Concrete in Europe." by A. L. Colby.

Designs for Dam

After careful study of the authorities quoted above and of all available facts bearing on the subject, the engineers entrusted with the preparation of plans for the Stony River dam decided that it would be perfectly safe to build the structure as a hollow dam of reinforced concrete. Four different types were considered:

(1) The Ambursen Design (Fig. 1) patented by the Ambursen Hydraulic Construction Co., of Boston, Mass., and used successfully since 1904, in more than 70 dams.

(2) The Ransom Design (Fig. 2) patented by William M. Ransom, of Providence, R. I., and now owned by the Hydraulic Properties Co., of New York. This type has been used in several dams.

(3) The Morton Type of Dam (Fig. 3) patented recently by Walter S. Morton, Hydraulic Engineer, New York. In this design the deck is supported by inclined columns instead of the usual buttress.

(4) A new type of dam, designed by W. S. Edge (Fig. 4), Chief Engineer of the Hydraulic Properties Co.

Any one of these types could be successfully adopted, if the details were properly designed. Specifications for the construction of the dam were drawn up and four construction companies were invited to present bids, accompanied by detailed plans for building the dam.

Bids on the types Nos. 1, 3 and 4, as noted above, were received from four different contractors and were found to vary between $140,000 and $198,475, the lowest bid being on type No. 3, a design which had never been applied to actual construction. After consideration of the various bids a contract was finally made with Frederick G. Webber, President of the Webber Construction Co., and the Ambursen Hydraulic Construction Co., of Boston, whereby Mr. Webber contracted to build an Ambursen Dam (as shown in Fig. 1) across Stony River for $140,000, plus the cost of the cut-off walls at unit prices, the West Virginia Pulp & Paper Co. agreeing to pay the Ambursen Co. for the necessary license and plans. Under this contract the dam is to be completed, barring delays beyond the control of the contractor, by Jan. 1, 1913.

Tests of Waterproofing Compounds

In deciding upon the details of the construction of the dam, the advisability of waterproofing the concrete of the deck of the dam, either by mixing a suitable compound with the cement or by using a coating of plaster or paint on the upstream side, was carefully considered. During the last decade a number of waterproofing compounds have been put on the market and the so called "integral method" of waterproofing has been successfully used in a number of places, especially in the foundation walls of buildings. Some waterproofing compounds have a deleterious effect on the cement, but others are free from this objection.

A number of pieces of masonry which had been waterproofed by the integral method were inspected. Samples of six different kinds of waterproofing compounds were obtained and were sent to the Rensselaer Polytechnic Institute at Troy, N. Y., to be tested as regards their waterproofing qualities and the effect they produced on the strength of the cement. The chemists of the paper company were asked to report on the chemical effects on the cement.

The compounds tested were as shown in Table I.

Mixtures of each compound were made with one part of cement and two parts of clean quartz sand and the percentage of waterproofing mentioned in the above table and prescribed by the manufacturers. The samples to be tested were left one day in air and 34 days in water. The effect on the strength of the mortar is shown in Table II.

The tests were made by Prof. T. R. Lawson. The figures given in the table are averages of four tests for each compound.

While the tests made were not numerous enough nor continued sufficiently long to give conclusive results, they show that the admixture of any of the compounds with the cement always diminished somewhat the tensile strength of the mortar. Tests made recently for the Department of Water Supply, Gas & Electricity of the City of New York gave similar results. This diminution of tensile strength may be less appreciable in tests for longer periods.

The watertightness of mortar mixed with the waterproofing compounds was tested in the following manner: Blocks, 4x4x6 in. in size were cast and a ¾-in. pipe, open at the ends, was embedded in the center of each block. After the blocks had set 38 days in water they were weighed and subjected to a water pressure of 75 lb. per sq.in. through the pipe for a period of 72 hr. The blocks were then weighed again, with results as shown in Table III.

None of the cubes showed loss of water through the mass when subjected to the water pressure and they all appeared to be practically watertight.

The first decision reached by the engineers of the paper company was to use a good waterproofing compound in the concrete of the deck of the dam, where watertightness is of the utmost importance. A contract was drawn up for the waterproofing containing the following clause:

> The contractors hereby guarantee and warrant that the water-proofing, used in the concrete herein provided for, will make the same absolutely waterproof for a period of five years from the time water is impounded in said dam, under the head to which it is to be subjected, and if said concrete shall not prove absolutely waterproof for that entire length of time, the contractors shall return to the company the money it has paid them for the waterproofing, with 4% interest thereon.

In spite of the severity of this requirement, there were six companies manufacturing waterproofing materials that were willing to comply with this condition and to give bonds to insure the carrying out of the contract.

However, the engineers in charge took under consideration the fact that the Ambursen Hydraulic Construction Co. has made the decks of the many dams it has built practically watertight by using a wet mixture of 1:2:4 concrete. In view of the reduction in tensile strength of mortar containing a waterproofing compound, indicated by the tests given above,

TABLE I. LIST OF WATERPROOF COMPOUNDS TESTED

Trade Name	Manufacturers.	Per cent used
Shamrock	McCormick Waterproofing Portland Cement Co. St. Louis, Mo.	3
Medusa	Sandusky Portland Cement Co. Sandusky, Ohio.	4
Metal-crete	Klein Manufacturing Co. Cleveland, Ohio.	5
Marvel	Goldstein Waterproofing Products Co. New York.	1
Crude Oil.	.....	10
Integrol	Wemlinger Steel Piling Co.	1 in 25 parts of water

TABLE II. STRENGTH OF MORTARS WITH AND WITHOUT WATERPROOFING COMPOUNDS

(Lb. per sq. in.)

Compound	Tensile	Compressive
1:2 Cement* & Sand	490	4655
Shamrock	469	4136
Medusa	417	3889
Metal-Crete	454	5055
Marvel	466	3412
Crude Oil	362	4509
Integrol	391	....

TABLE III. TEST FOR ABSORPTION.

Compound	Weight of Cubes	Weights after Pressure Test
	grams	grams
Shamrock	3320	3309
Medusa	3532	3559
Metal-crete	3542	3526
Marvel	3508	3512
Crude Oil	3454	3450
Integrol	3462	3453

it was finally decided by the engineers not to use any integral waterproofing, but to build the proposed dam exactly according to the methods adopted by the Ambursen Co. and to waterproof the deck eventually, should it be necessary, by painting or coating the upstream face with a suitable mixture. Such a method would not affect the strength of the dam and would be much cheaper than the "integral method." A bid was received to waterproof the deck of the dam in this manner, at a cost of about $350. Which of the two methods of waterproofing will give the better results can only be determined by actual experience.

John G. Luke is President of the West Virginia Pulp & Paper Co., and the engineers of the company are R. P. Bloss, engineer in charge, G. H. Bayles, resident engineer, and F. G. Ten Broek, consulting mechanical engineer. Geo. F. Hardy made the preliminary investigations to find a suitable site, and the writer was retained as consulting engineer for the entire work.

Plants for Washing Lean Iron Ores

The iron-ore deposits of the western Missabe range, in Minnesota, include a number of deposits of lean ores combined with a considerable proportion of sand or silicious material, and those require some treatment for the removal of the sand and inert matter before the ores are of commercial value. Two companies are now operating washing plants for the treatment of ores of this class, and one of these has a supplementary concentrating process. In both cases the ores are obtained from open-pit mines.

Plant of the Oliver Iron Mining Co.

According to a paper by J. N. Roherty in "The Wisconsin Engineer" (University of Wisconsin), the Canisteo district has a large proportion of lean ores of a silicious character, which occur in alternating layers of hard hematite and free sand; varying quantities of taconite (rock) and paint rock are found also in these ores, and these three impurities have to be removed to render the ore fit for use. In 1907 an experimental washing plant was built at Coleraine, Minn., and the results were such as to warrant the development of the process on a commercial scale. The Oliver Mining Co., therefore, built the present Trout Lake plant (near Coleraine), and this was put in operation in 1910. The following particulars of this plant are taken in part from the paper mentioned above, but have been revised for us by an officer of the company so that they represent present working conditions.

The mill is 255x162 ft., and the tracks at the top, on which the crude ore is delivered, are 90 ft. above the tracks on which the washed or concentrated ore is shipped. The cars dump the ore into bins from which it is drawn as required and passes to a bar screen or grizzly having 8-in. openings between the bars. Large pieces of ore are broken by sledges, but waste rock and boulders are thrown into chutes leading to a rock bin. The material falling through the screen (assisted by a jet of water) goes to a horizontal revolving conical screen 20 ft. long, having 2-in. holes, and after pasing through these holes it is delivered to two inclined washing troughs set at an inclination of 1:12. The troughs are 28 ft. long, and each has a pair of longitudinal shafts with blades or paddles which gradually work the coarse material to the upper end, where it is discharged and goes then to the ore bin. A stream of water is fed continuously to the troughs and the overflow carries off the finer material. The oversize from the revolving screen is delivered to a belt conveyor, and men standing beside this pick out the rock and throw it into chutes, while the ore passes from the end of the belt into a chute leading to the ore bin.

The fine material carried off with the overflow from the washes is passed through a chip screen (to remove the floating material) and then to two settling tanks arranged in series. The sediment collected here is run into a "turbo" washer, 18x4 ft.; this is divided into sections, each of which has the bottom perforated with holes through which water is admitted under pressure, thus serving both to wash and classify the concentrate. The overflow from the "turbo" washer goes to another settling tank, the overflow from which is waste water, while the material collected by sedimentation is delivered to Overstrom tables, having corrugated surfaces and over which water is kept running. The sand and lighter material is carried off with the water, but the iron particles are caught by the corrugations or riffles and delivered at the end of the table by the rocking motion of the latter. The material thus recovered includes concentrates and tailings. The first are pumped by Frenier spiral pumps to a drainage tank and delivered thence to the ore bins; the tailings go to waste.

Plant of the Wisconsin Steel Co.

The same system of washing, but without the concentrating treatment, is employed in the more recent plant of the Wisconsin Steel Co., near Nashwauk, Minn. (a few miles from Coleraine). This plant treats a soft red hematite, which requires the removal of the sandy deposits occurring with the ore. As described in the *Mining and Engineering World*, the ore is delivered by cars to a 250-ton bin and thence taken to the mill by a 36-in. belt conveyor 150 ft. long. This discharges upon an inclined bar screen, the boulders falling beyond the screen while the ore passes through and falls into a chute which feeds it to horizontal revolving screen having 2-in. holes spaced 3 in. apart.

This screen is on the top floor of the mill. It is 20 ft. long, tapering from 3½ ft. diameter at the feed end to 7 ft. at the discharge. A spray of water is thrown upon the screen. The oversize from the screen goes to a belt conveyor on which the waste rock is picked out by hand and thrown into chutes leading to a bin, while the ore is discharged from the belt into a chute leading to another bin. From these bins or pockets the rock or ore can be delivered to cars by spouts.

The finer ore which passes through the perforations of the screen is delivered to the lower end of two inclined washer troughs 25 ft. long, each of which has a pair of shafts fitted with blades so shaped as to feed the heavier material (nearly pure ore) toward the upper or discharge end of the trough. The finer material passes off with the overflow and is delivered by gravity to a pair of settling tanks. By means of valves or spigots in the bottom of each tank, the material is drawn off and delivered to an auxiliary washer, the shafts of which run at 9 r.p.m. instead of 25 r.p.m., as in the first washer. The waste water from the settling tanks and auxiliary washer goes to a settling basin to deposit its sediment before being discharged finally to the waste flume.

All machinery is driven by electric motors and the mill has a capacity of handling 4000 tons of ore daily. It was designed and built under the direction of Mr. Leonhauser, Chief Engineer of the company.

A Steam Superheater attachment of novel design for water-tube boilers has recently been put out by the Heine Safety Boiler Co., of New York City. The features of design are intended to secure a reduced surface of steam coils and control over the volume of gases which pass through the superheater. The superheater as constructed consists of a header box into one side of which are inserted U tubes made of 1½-in. seamless stock. The header box is divided into three compartments so that the steam makes four passes in going through the superheater. The header box, with its tubes, is located at the side of the shell toward the front of the boiler and it is walled in to separate it from the other part of the boiler. A small flue, built in the side walls of the boiler setting, by-passes hot gases from the chamber back of the bridge-wall up into the superheater chamber. Here the gases make two passes over the superheater surface and escape through a damper into the space, around the main drum, leading to the uptake. The volume of hot gases used through the superheater can be controlled by hand or automatically, by manipulating the damper noted.

A Convenient and Economical Method of Subdividing Tracts of Irrigated Lands

W. C. McNown*

In the cutting up of irrigated lands in the West for disposal to settlers, engineers and surveyors have generally followed the practice of using the U. S. Government quarter sections as the unit, and hence the boundary lines have been coincident with, or parallel to, section lines.

Anyone with experience in the application of water to land for the purpose of irrigating crops will appreciate that such a practice is not in accord with the best interests of the farmer. Unfortunately few engineers or promoters have actually undertaken the task of applying water to crops, and they do not consider that nature has not laid out irrigable tracts in squares or rectangles, where the topography is at all broken. It remained for a layman to initiate and put into practice what has proven to be an ideal method of subdividing irrigated lands.

When the Walla Walla Irrigation Co. began to subdivide and develop its 7000 acres of rolling bench land, lying a few miles southwest of Walla Walla, Wash., its president and manager, E. C. Burlingame, an irrigator of wide experience, directed his engineers to subdivide the land into parcels conforming with the topography, each containing one or more irrigable units. The project is known as the Gardena Contoured Tracts, so called because of the method first used there in the surveys for subdivision.

In this earlier development the contours were determined for 1-ft. intervals, and when these were placed upon the map the roads and boundaries were first projected in the office and then transferred to the ground. In the later work done by the writer, no contour map was made, the lines being worked out upon the ground after taking some rough topography with which to plan the road system.

It will be noted from the accompanying map that the land is in the form of a plateau breaking away into low ridges separated by shallow draws. The roads and boundaries are in the bottoms of draws or on the tops of ridges wherever possible. The advantages of such an arrangement will be apparent to an experienced irrigator and may be enumerated as follows:

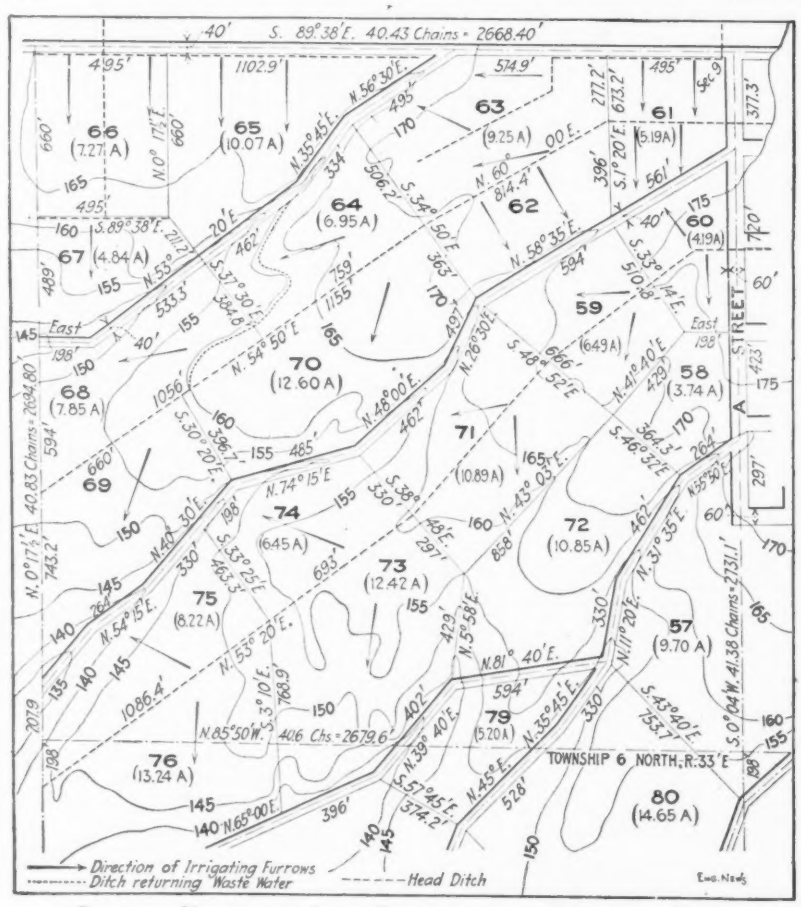
(1) Each owner or operator has one or more irrigable units, which, after leveling with fresno scraper and float, he can work without any waste land and absolutely without flume or pipe line. It should be said that the furrow system of irrigation is here used exclusively.

(2) If a man wishes a larger quantity of land he may purchase a number of such tracts in a desirable arrangement. As for example, one man owns and operates in a body lots 61, 62, 63, 64, 70, 68 and 69, containing a total of 56.29 acres, exclusive of roads. One headgate and ditch serves his entire holdings. Contemplate for a moment what a predicament he would have been in had he purchased, say, a 40-acre government subdivision out of this quarter section.

(3) All waste water passes to the boundary lines or roads and is carried along them until such time as it can be returned to the head ditches, instead of discharging through the fields of the farmer next below. Since it is impossible to irrigate by the furrow system without a considerable quantity of waste water, a vexing problem is thus solved.

As the company has acquired its holdings slowly, many roads have of necessity been placed upon section lines, but wherever possible section lines have been ignored. Even the Washington-Oregon State boundary line, which passes through this body of land, could not be used as a suitable location for road or subdivision line, and while it is necessary to recognize it in the filing of plats and the giving of deeds, the orchardist, or gardner, after acquiring his title, will operate his land without reference to such arbitrary lines.

This system has been in use for about seven years, and its advantages become more clear with time. The writer has used it wherever he has been called upon to subdivide lands being placed under irrigation. It requires large effort sometimes to convince a promoter that his lands should not be laid out "square," but in the end he usually sees the advantage. There is also a strong prejudice on the part of owners and operators of land in favor of having their holdings in rectangular form, which is difficult to understand when one considers how often the fields inside the farm are divided according to the topography and soil into irregular parcels. There is also a prejudice on the part of engineers in favor of long courses on boundaries and long tangents on roads, which must not be indulged in following this system. Lines must be broken to conform with the topography or serious difficulties arise.



CONTOUR METHOD OF LAND SUBDIVISION FOR IRRIGATION TRACTS

*Civil Engineer, Walla Walla, Wash.

Standard Tests of the Efficiency of Sewage Treatment

By C. B. Hoover*

Laboratory testing to show the efficiency of sewage treatment must be revised and modified in order to yield data which are relevant to the problems involved. The standardization of these tests and methods of analysis is very desirable in order that results secured at the several sewage testing stations and works may be comparable.

Sewage treatment, from both sanitary and asthetic points of view, must become a part of the activity of many municipalities in the future and the proper performance of this function should not fail because of incompetency which may be shown in both the design and the operation of the works.

In sewage treatment work the final result is a mean result of the operation of physical, chemical and biological agencies, and wherever life processes are introduced into a problem, analytical difficulties become greatly multiplied. We are now beginning to realize that the old methods of analysis are not satisfactory and within the next few years we are going to witness a revision and modification of some of the old methods, an absolute discarding of others, and a working out of new practical methods of testing.

This article reviews the subject of sewage analysis, or testing the results of sewage treatment, from the viewpoint just stated. A comparison of the tests made at various experimental and permanent laboratories is given for the purpose of showing the extent to which uniformity prevails or is lacking. A valuation of some of the leading tests is presented.

*Chemist-in-Charge, Sewage Purification Works, Columbus, Ohio.

The disposal of sewage is almost entirely a municipal function which is performed in response to the aesthetic and sanitary demands of the community. Public officials understand that there should be no expectation of a direct financial return from an investment of this kind and this fact has engendered a diffidence on their part regarding the maintenance and successful and efficient operation of such works.

There are two things which are needed today in this branch of municipal service. The first is a more active interest in and a more generous support by public officials, and the second is the agreement upon or adoption by the several testing stations and sewage works, of certain standard tests and analytical methods to be used in testing and expressing the efficiency of the various methods and processes of sewage treatment.

The first need is one which, when met, will result in the betterment of the individual plants, and when the second condition is established, the results of operation from various plants may be accurately compared and more rapid progress in this line of public service may be reasonably expected. It is the purpose of the writer to deal with this latter condition, not in a critical way, but with the hope that those who are directly engaged in this line of work may be united in an effort to standardize the methods of analysis and testing of sewage and sewage effluents.

In order to get an accurate comparison of the characteristics of the sewage of two cities with respect to the ease or difficulty of treatment, or in order to make a fair and accurate comparison of the efficiency of sewage treatment at different places, it is essential that representative sampling and standard methods of analysis and testing be employed in getting the results which are to be the basis of the comparison.

Engineers and public officials have nothing but the reported results from the various testing stations and sewage works upon which to base their judgments and when these results are not representative and the values reported from the different laboratories are not comparable because of faulty testing and analytical methods, mistakes in design and operation will be made and consequent economic losses will be incurred.

In solving a sewage problem it seems to the writer that when the work is done in a logical manner there are four distinct stages to be passed through from the inception to the completion of the scheme. The first stage is the determination of what is needed in a general way to correct the conditions which are complained of. The second stage is the determination of the best and most economical processes which will modify the sewage to the desired degree. The third stage is the design and construction of works in which economy of construction, ease of operation, and efficiency as to the production of the proper final product, are combined. The fourth stage is to provide competent supervision for the new works. The problems which the first two stages present are largely of a biological nature and should be entrusted to some one who is thoroughly familiar with both the art and science of sewage treatment, analysis, and testing. Engineering assistance should be supplied when needed. The third stage is essentially an engineering problem and should be entrusted to one who is not only a good engineer, but who has specialized in this line of work and who has had enough operating experience to know the many little details which mean so much from the operating point of view. The fourth stage is one which, from a technical viewpoint, presents largely chemical and biological problems, but the one to whom the supervision of a sewage works is to be entrusted ought to have other qualifications besides those of a technical nature. Geo. W. Fuller, in his recently published book on "Sewage Disposal," has discussed on page 195 the qualifications of a sewage-works manager or supervising chemist. In addition to what Mr. Fuller has said, the present writer would add that unlimited patience and great faith are essential because the one who is in charge of such works is apt to be the only person in the community who is interested in this work or who cares whether things are right or wrong.

The tests and methods of analysis which are employed in controlling the operation of a sewage works, or in testing the efficiency of various experimental processes, ought to give results which indicate as closely as possible the success of the treatment with respect to the prevention of harmful stream pollution.

It is impossible to make a reliable preliminary and experimental study of a sewage problem unless the methods of analysis which are employed reveal the essential facts. The purification of sewage and the self-purification of streams are effected by physical, chemical and biological agencies and it is almost impossible to measure these activities by means of artificial chemical tests or analyses. Agricultural chemists report that it is difficult to measure the fertility of a soil by chemical analysis because the availability of the fertilizing elements is only partially revealed by the analysis. Likewise in the customary quantitative chemical analysis of sewage there is no discrimination between harmful and harmless material with respect to stream pollution. The most trustworthy way to determine the fertility of a soil is to let the growing plant make the analysis, i.e., the productiveness of the soil will be indicated by the characteristics of the growing plants. Here the fertility of the soil is studied by observing the operation of the natural forces.

In sewage work practically the same kind of a proposition confronts us and in the future we are going to get our most reliable analytical data from the

TABLE I. ROUTINE TESTS AND ANALYSES MADE IN TWELVE LABORATORIES OF SEWAGE TESTING STATIONS AND SEWAGE DISPOSAL WORKS IN THE UNITED STATES

	Akron	Baltimore	Brockton	Chicago	Columbus	Columbus	Gloversville	Philadelphia	Plainfield	Reading	Waterbury	Worcester
Free ammonia	x	x	x	x	x		x	x			x	x
Albuminoid ammonia,												
Total			x									x
Dissolved			x									x
Suspended			x									x
Residual organic nitrogen,												
Total	x	x		x	x		x	x			x	x
Dissolved	x			x	x		x				x	x
Suspended	x			x	x		x				x	x
Oxygen consumed												
Total	x	x	x	x	x	x	x	x	x	x	x	x
Dissolved	x		x	x	x		x	x			x	x
Suspended					x		x					x
Settling								x				
Colloidal								x				
Residue on evaporation,												
Total			x		x							x
Dissolved			x		x							x
Suspended	x	x	x	x	x	x	x	x	x	x	x	x
Loss on ignition,												
Total			x		x							x
Dissolved			x		x							x
Suspended	x	x	x	x	x		x	x			x	x
Fixed residue,												
Total					x							x
Dissolved					x							x
Suspended	x			x	x		x	x			x	x
Sulphur,												
Total												x
Dissolved												x
Suspended												x
Iron,												
Total				x								x
Dissolved												x
Suspended												x
Nitrites	x	x	x	x	x	x	x	x	x	x	x	x
Nitrates	x	x	x	x	x	x	x	x	x	x	x	x
Dissolved oxygen	x	x	x	x	x	x	x	x		x	x	x
Methylene blue	x	x	x	x		x	x	x	x	x	x	x
Chlorine	x		x	x	x	x	x	x			x	x
Fats				x	x		x	x			x	
Alkalinity	x			x			x	x			x	
Carbonic acid				x	x		x				x	
Whole numbers of Bacteria		x		x	x	x	x	x	x	x	x	
Dissolved oxygen consumed						x						

use of practical methods of testing in which artificial conditions are as completely eliminated as possible. To experienced sewage analysts this idea is not a new one. In speaking of the methods of measuring organic matter, Geo. W. Fuller says: "But generally speaking, the results of such tests are a disappointment, as they show but little as to the character or source or deoxygenating properties of the organic matter, and about which knowledge is needed for the advancement of the art of sewage disposal."* Dr. Arthur L. Lederer, in his studies at the sewage-testing station of the Sanitary District of Chicago, has noted the same thing.

In looking over the reports from the various sewage-testing stations and sewage-disposal works, it will be found that a variety of tests and analyses constitute the routine work in the different laboratories. Local conditions often call for certain analyses at one place which are not at all needed at other places and the experience that has been gained during the last eight years has shown that many of the analyses, which formerly were a part of the routine, are not essential, so that the tendency has been to reduce the laboratory routine.

*"Sewage Disposal," page No. 49.

The routine tests and analyses which have been employed at the various testing stations and sewage works during the past eight years are indicated by Table I.

An inspection of this table will show that the tests which are most frequently employed are the following:

Free Ammonia.

Organic Nitrogen, total, dissolved, and suspended.

Oxygen Consumed, total and dissolved.

Suspended Matter, total, volatile, and fixed.

Nitrites, Nitrates, Dissolved Oxygen, Chlorine.

Whole Numbers of Bacteria, and the Methylene Blue Test.

These tests and methods of analysis are of interest because of the diagnostic value of the data which result from their use and also because of the comparability of such data from different laboratories.

Results secured at the Philadelphia, Gloversville and Columbus sewage-testing stations indicate to a marked degree that the strength of sewage and the success of its treatment with respect to harmful stream pollution are not revealed in a quantitative way by the results of free ammonia, organic nitrogen and oxygen consumed determinations. None of the above tests or methods of analysis are satisfactory for this purpose and for that reason the writer uses a method* whereby the avidity of sewage and sewage effluents for oxygen is measured by determining the parts per million of oxygen consumed in known dilutions of sewage and pure water after an incubation at 37° C. for 24 hr. In this test an effort is made to approximate natural conditions in which natural forces operate.

The determination of suspended matter is a measure of the success of the sedimentation processes, but as ordinarily carried out it does not differentiate between the solids which it is practicable to remove by sedimentation and those which should not be expected to be so removed. The determination of the efficiency of sedimentation by comparing the capable-of-settling solids before and after tank treatment, does not seem to the writer to be a satisfactory solution of the problem. In the experience of the writer the determination of volatile suspended matter is not worth while because this data does not consistently tie up with results of stability tests.

Nitrites and nitrates are an indication of the extent and completeness of the mineralization of the nitrogenous matter, but are of no value to the effluent except in cases where an almost complete deoxygenation of the water in the stream into which the effluent is discharged is permissible. In streams where self-purification takes place rapidly, a fairly complete depletion of oxygen might be permissible for a short distance below the sewage works outfall in some instances. Dissolved oxygen is the big asset of a sewage effluent and the more the better. The amount found is usually an indication of the completeness of aëration and oxidation and wherever sprinkling filter effluents are settled the liquor ought to be discharged from the basin or tank in a way to promote aëration so that the liquor which is discharged into the stream will be supplied with oxygen. At Columbus the chlorine results simply indicate the times when our sewage has been diluted by ground and surface water, the reduction in the chlorine content increasing with the dilution.

*See Engineering News, March 16, 1911.

TABLE II. OXYGEN REQUIREMENTS OF SPRINKLING FILTER EFFLUENTS

Mean Values for	Parts per million of dissolved oxygen consumed by the dilution-incubation method after 24 hours at 37° C.	Parts per million of available oxygen consumed by undiluted samples after 24 hrs. at 37° C.
July 1911	32	15.7
August 1911	27	19.1

TABLE III. SPRINKLING FILTER EFFLUENTS, COLUMBUS SEAWGE WORKS

Mean Values for	Parts per million of dissolved oxygen consumed by the dilution incubation method after 24 hours at 37° C.	Parts per million of available oxygen being the sum of the dissolved oxygen and the oxygen of the nitrites and nitrates	Relative stability values	Required oxygen in parts per million computed from the available oxygen and the relative stability value
July 1911	32	17.0	53	32
August 1911.	27	19.7	63.5	31

Bacterial determinations are most important where bacterial pollution of the stream is most serious. The results which the writer has secured at Columbus indicate that the percentage reduction in the total number of bacteria by the purification processes is practically the same as the percentage reduction of intestinal species. The danger of infecting a public water supply by discharging the effluent of the Columbus works into the Scioto River is so slight that bacterial reduction is of minor importance.

The methylene blue test is designed to determine in a general, simple, and practical manner the stability of a sewage-works effluent. The writer has applied this and three other stability tests to daily composite samples of the effluents from the Columbus sprinkling filters for the past three years. The results of the methylene blue test are apt to be misleading to some because an effluent may give a very satisfactory stability value and at the same time be only about one-half as good as the result of this test would indicate. From one-half to two-thirds of the available oxygen in our sprinkling filter effluents comes from the nitrites and nitrates and this oxygen will not be brought into service until at least

TABLE IV. OXYGEN CONSUMED DATA FOR VARIOUS SEWAGE TESTING STATIONS AND WORKS

City	Kind of plant	Digestion: Method*	Digestion: Time, min.	Digestion: Temperature, deg.C.
Akron	Experimental	A	30	100
Baltimore	Experimental Constructed	A	30	100
Brockton	Constructed	A	5	100+
Chicago	Experimental	A	30	100
Columbus	Experimental	A	5	100+
	Constructed	B	5	100+
Gloversville	Experimental	A	5	100+
Philadelphia	Experimental	A	30	100
Plainfield	Constructed	A	5	100+
Reading	Constructed	A	5	100+
Waterbury	Experimental	A	5	100+
Worcester	Constructed	A	2	100+

*Method A: The volume of potassium permanganate, which is added at the start, is such that there will be an excess at the end of the period of digestion.
Method B: The potassium permanganate is added from time to time during the period of digestion in amounts just sufficient to preserve the pink color.

TABLE V. STABILITY DATA FOR VARIOUS SEWAGE TESTING STATIONS AND WORKS

Name of city	Kind of plant	Kind of sample used*	Conditions of incubation: Temp., deg. C.	Conditions of incubation: Bottles sealed	Conditions of incubation: Time
Akron	Experimental	Single (1)	Var.†	No	Until decolorized
Brockton	Constructed	Single (1)	Var.	No	Not more than 7 days
Chicago	Experimental	Single (1)	20	No	Not longer than 4 days
Columbus	Constructed	Comp. (12)	37	Yes	Not longer than 7 days
Gloversville	Experimental	Single (1)	20	No	Not longer than 4 days
Philadelphia	Experimental	Single (4)	20	No	Until decolorized
Plainfield	Constructed	Single (2)	Var.	No	Not longer than 10 days
Reading	Constructed	Single (1)	Var.	No	Not longer than 7 days
Waterbury	Experimental	Single (1)	37	No	Until decolorized
Worcester	Constructed	Comp. (24)	Var.	No	Not longer than 14 days

*The numbers in parentheses indicate the number of portions in each composite samples and the number of single samples tested per day.
†Variable; that is, constant temperature incubator not used.

80% of the dissolved oxygen has been consumed; consequently unless a fairly complete deoxygenation of the water of a stream is permissible, the nitrites and nitrates as sources of oxygen should not be considered. Another feature of the methylene blue test which may mislead is that the consumption of oxygen in mixtures of pure water and effluents is greater and more rapid than it is in undiluted samples. This is shown by Table II.

The methylene blue test gives required oxygen values in parts per millian which approximate the parts per million of dissolved oxygen consumed by the dilution-incubation method after 24 hr. at 37° c. This is shown by Table III.

The relative stability value is the percentage which the available oxygen is of the required oxygen. The methylene blue test is a good one, but the interpretation of results secured by its use is not so easy as it is too often thought to be.

In regard to the comparability of results secured in different laboratories the writer will present only two tables (IV and V), which are sufficient to indicate the need of a getting together by sewage analysts.

There are two things which prevent permanganate oxygen consumed values from being comparable; one is the unscientific nature of the determination as ordinarily conducted, and the other is the varying procedures which are followed in different laboratories. The unscientific nature of this determination was discussed by the writer in an article in ENGINEERING NEWS of Mar. 16, 1911.

The variety of ways of conducting the methylene blue test is to be regretted. The writer is not prejudiced in favor of any particular temperature of incubation for this test, but believes that two things are essential, namely, the sealing of the bottles and constant temperature incubation.

The art and science of sewage treatment and sewage testing and analysis would be rapidly and effectually advanced if there were a national association of sewage analysts, sewage-works managers, and others who are properly qualified for membership. Such an association could work for the promotion of the art and science of sewage treatment, standardize methods of analysis of sewage and sewage effluents, and publish a technical journal in which could be found all the best literature relating to this branch of municipal service. It is the hope of the writer that this suggestion may commend itself to all who are closely associated with and interested in the problems of sewage purification and disposal.

Letters to the Editor

Wood in Compression; Bearing Values for Inclined Cuts

Sir—The writer desires to call attention to a few points on Prof. Howe's article, "Wood in Compression; Bearing Values for Inclined Cuts," published in your issue of Aug. 1, 1912.

At the outset he misquotes Prof. H. S. Jacoby's formula when he states that p and q represent, respectively, the normal intensities on the ends and across the fibers, when, as a matter of fact, they represent the allowable or safe normal intensities on the end and across the value of n as given by Prof. Jacoby's formula is not independent of the physical properties of the wood.

The author advances a formula which he claims to be theoretically true, but the writer is inclined to doubt this, since when θ equals 90° the formula gives for n a value $\frac{1}{2}(p + q)$ when it should be p.

The writer cannot agree that a formula based on equal deformations across and on the ends of the fibers is a satisfactory one, when it is well known that almost any wood will safely stand a much greater deformation across the fibers than on the ends of the same and still regain its original form when the load is taken off.

The writer believes that the true curve should and will be tangent to the horizontal at the 90° as well as at the 0° point, and had the author taken points between 75° and 90° the writer feels confident that he would have found such to be the case.

The author fails to state the size of the blocks of wood used in the tests as well as the area of bearing taken. The knowledge of these facts is of much importance to one making a study of the article and should most certainly have been given.

The writer wishes to express his appreciation to the author for having taken up the study of this subject, which is one on which very little has ever been done experimentally, and yet it is only through experiments that a formula of any value can ever be developed.

ROLAND P. DAVIS.
335 E. State St., Ithaca, N. Y.,
Aug. 21, 1912.

How Engineers Can Aid Civic Advance and Raise the Public Estimate of the Profession

Sir—The Cleveland Engineering Society is attempting something definite to help create in the public mind a position for the engineer commensurate with the responsibility that is his in an advanced community. It is expected that mutual benefit from such efforts will accrue to both the public and the engineer by the former receiving service in the guidance of civic affairs from a source of special

training not now generally utilized, while the latter gains prestige important to the growth of the profession.

Although in our Society we make studies of a constructive nature in community affairs, results beneficial to the public are attained in but small measure unless machinery is brought into play to educate the people to intelligent action. The newspapers are the eyes, almost the intellect, of the diverse population of a great city. Through this channel, often inaccurate, but averaging up generally right, we must hope to reach the greatest number.

An illustration of the above is the report of the Committee of the Society on Technical Education in Cleveland, published in the July issue of the *Journal*, and the publicity given the findings of the committee by the daily newspapers of the city. Clippings are inclosed from the *Plain Dealer*, the *Leader* and the *Wächter und Anzeiger*.

The recent action of the Society in making definite recommendations to the Mayor and City Council for the solution of the local water-supply problem prompted Mayor Baker to say:

> There was a scientific problem proposed in Cleveland just a short time ago involving the question of the filtration of our water supply . . . distinctly a scientific question that affected the life and health of the entire community. . . . It was in every way the sort of question that ought to have invited from the engineering profession their patriotic public-spirited interest in its solution. And I want to take this first public opportunity to express my own very grateful appreciation for the fact that the minute that problem was proposed the Cleveland Engineering Society began its study and devoted much time to it, and gave to the Council and the executive officers of the city a most helpful report. It was an unremunerated and voluntary service . . . and I am glad of this opportunity to express my gratitude for it.

To the question often raised, "what can engineers do to improve the standing of the profession" the incidents related in this letter are a partial answer.

C. E. DRAYER.

9292 Hough Court, Cleveland, Ohio, Aug. 16, 1912.

[As showing both the nature of the investigation of the public schools, noted in the foregoing letter, and the way the report mentioned was handled by the daily papers of Cleveland, we reprint a portion of an article from the Cleveland *Leader* of Aug. 14, 1912:

> The committee consisted of Willard Beahan, J. F. Barker, William Knox, G. F. Burrows, C. F. Dutton, Jr., and T. G. Protheroe. It made personal inspection of Commerce High, Tech High, East High, Case School, Warner & Swasey apprenticeship school and the Lake Shore apprenticeship schools.
>
> The stamp of approval was placed upon Tech and Commerce High schools as furnishing excellent training for the future needs of pupils in private life and industrial occupation. The committee reported, however, that the equipment of Commerce High was wholly inadequate. A new building, designed to meet the special needs of the pupils and liberally equipped with modern apparatus is urgently needed, it says. Opportunity is afforded to gain a first-class education in engineering in the apprenticeship schools.
>
> The committee further states that manual training in the grades and academic high schools needs further development. The committee thinks that the vocational bureau should be made up of representativs of various organizations interested in the welfare of the child and working in coöperation with the schools and social settlements.
>
> Discussing the general administration of the schools the committee says that the greatest need is the gathering of authority in a single head able to unite the several elements into one harmonious whole.
>
> "The best results will be attained when the character of those in charge of the work is such as to command the admiration of the pupils and develop a spirit of emulation," they add.
>
> In submitting its report the committee says that it investigated the schools, not as trained educators, but as engineers who have charge of the direction of the energies of the pupils after they enter employment. Quoting from the report:
>
> The efficiency of Cleveland's educational system, when the number of pupils entering first grade and those graduating is compared with the supplying of pupils with something saleable is less than 50%. The wealth available to a community through the wise training of its children is greater than can come from any other source. It is a cause for wonder when we are constantly talking of conservation and efficiency that so little attention is paid to the waste of human energy.
>
> Investigations of this sort, confined to subjects on which engineers can speak with authority, carried out impartially and reported on in such a way as to be readily understood by the general public, would do much to aid in civic advance and raise engineers and engineering in the estimate of the general public. Doubtless the press of other cities than Cleveland would gladly give publicity to reports on such investigations, as did the papers of that city.—ED.]

Various Questions

SIR—The editorial in your issue of Aug. 1 on fixing the blame for criminal negligence and the article on "Young Old Engineers," by A Veteran, in your issue of Aug. 8, suggest to the writer some reflections. In the latter, the problem seems to be what shall be done with "the unfit"? Well, why not make "experts" of them to serve in cases where there are instances of criminal negligence to be investigated. It is notorious that "experts" differ so that any discrepancies in the findings of these "has-beens" would be immaterial. The old saying is: "Who shall decide where doctors disagree?"—only another doctor, of course.

The case of the has-been is only less tragic than that of the "never-was" (to coin a new term). By hypothesis he is willing, conscientious, moral, he is just out-of-date, and his hope lies in the time when the shadow shall turn back ten degrees in the dial of Ahaz.

And yet "Art is long" (so much "longer" to some of us than to others) "and time is fleeting" and the true expert cannot be developed overnight nor even in a two weeks' session of a board of "Titanic" inquiry. And then there is the necessity (apparently) for a criterion or standard to judge who is the true expert, and who the "time server."

What are we to say as to such "progressive" proposals as the conserving the headwaters of the Mississippi at a cost, as you estimate, of, say, $1,300,000? What is a few (?) hundreds of millions of dollars to a "broad minded" statesman or engineer? Is not all modern history showing that the pessimist, the doubter, has no place in this age of the ever vaster, huger, more mastodonic, more titantic things; when dollars are poured out like water pouring through a crevasse in a levee; when two billion dollars in three years to "keep the peace" alone is only a starter; when ten thousand murders a year go not only unpunished but *justified* and ten thousand railroad accidents or rather deaths from accident must be counted as part of the price paid for "progress?" Is there no such thing as evolution evolving too rapidly? The answer is no! Emerson says "people ask 'What's the news?' as if the old were so bad." We shall only slowly—it seems—get better and some say we are not getting better at all. Think of Nietsche's "ruthless" man as the man we are coming to, not leaving behind.

The suggestion of one of your correspondent's that we be termed "energiers" instead of engineers seems to the writer not desirable since though there are many branches of engineering where energy is a chief part there are others where it is not such an important factor. But, ah! if there were any name we could adopt, were it dog-catcher, tumblebug, buzzard or louse, that would advance our pay and separate us from the common herd, from the "hoi polloi," and give us a status they would respect and never dare try to attain how overcrowded, truly, our profession would become, and not a few women in it, too—and "old women" at that!

JOHN WILKES.

Nashville, Tenn., Aug. 17, 1912.

Notes and Queries

Information regarding the design of spring mounted dancing floors is desired by a Southern engineer. He states that: "The floors are mounted on springs and are a great improvement over the ordinary construction." We trust that anyone possessed of this information will make it public for the benefit of a brother engineer and of the dancing portion of the human race.

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*Illustrated.

Engineering News

The need for generally accepted standards in sewage treatment, including both the objects to be attained and the tests to be applied to judge the degree of attainment, is discussed at some length elsewhere in this issue. The author of the article, C. B. Hoover, writes with the practical experience gained at the sewage works of Columbus, Ohio. His summary of the tests made at various laboratories and his remarks on the relative values of some of the tests in most general use might well serve to stimulate a general discussion of the subject. Mr. Hoover's suggestion for an association of sewage-works managers merits consideration although it makes one scowl to think of adding still another to the myriad of technical societies. Could not the same purpose be served in some other way?

The addition of New Orleans to the list of cities which have adopted the commission plan of government leads one to inquire where the movement is to stop. The plan has now been adopted by well toward if not quite three hundred cities, mostly within four years. At first only the smaller cities were included, but latterly several of a hundred thousand or more were added to the list, and now comes New Orleans, with its third of a million people in 1910. The accession of large cities to the commission-plan family will put the plan to some severe tests. Failure at many important points is bound to come unless better means than have yet been adopted are provided for selecting and retaining in office trained men as heads of the engineering and other highly technical forces. The present notion is that calling a man commissioner of this or that department qualifies him as an "expert." It does nothing whatever but "fix responsibility"—and what is responsibility without ability?

Contractors Responsibility For Accidents

The question of responsibility in accident cases will take on a new aspect if a recent decision of the highest court in Germany should be applied in court decisions and in practice in this country. The decision (reported in *Beton und Eisen* of Aug. 5, 1912) says in effect that construction work which involves any elements calling for engineering education or training must be carried on under the charge of persons having engineering training or else the contractors or directors of the work will be held to be negligent, and in case of accident recovery can be had against them on the ground of negligence and inadequate care in doing the work.

The case goes back some twelve years, when a steel bridge over the Peene River, at Demmin, collapsed under a crossing train during some bridge-repair work. Leaving aside the technical reasons for the collapse, the fact appears to have been that the contractor placed an experienced erector in charge of the reconstruction work, but did not have a technically trained engineer in charge. The court found that the causes of the accident were of such nature than a technically trained engineer would have been more fully appreciative of the difficulties and dangers of the several stages of the repair work, and would have better foreseen the necessary precautions, than a merely practical erector, who ordinarily is in the position of executing the directions of others. After the collapse the contractor was held liable for damages in a suit brought by one of the persons injured in the accident, but the suit just decided was brought by the government for damages to property.

The court found the direct cause of the accident to have been that some rivets had been removed from top-chord connections and had not been replaced by other connections sufficient to make the bridge secure. While this in itself may appear to imply negligence, the essential ground for the decision was the failure to place an engineer in charge of the work, as noted. The bearing of this on a wide range of construction operations will be evident to all concerned with engineering work.

The Decoration of Railway Bridges over City Streets

When railway bridges are to be built across important city thoroughfares, and specially when these thoroughfares are boulevards or parkways, there is frequently a demand on the part of the public and of the municipal authorities for some decorative treatment of the design, so as to provide structures somewhat in harmony with the surroundings and of more pleasing appearance than the ordinary bridge. This problem has solutions have been of varying character been encountered in many cities, and the and with varying degrees of success. The problem becomes insistent where much

track elevation work is concerned, and it has cropped up several times in Chicago in connction with the very extensive system of track elevation that has been in progress for several years. In the great majority of cases, however, bridges of this kind are extremely plain and simple structures.

It may be said, and has been said, that a structure properly designed to fulfill a certain purpose is essentially artistic in itself and that the addition of extraneous features for the sake of appearance is not art, and is not necessary. However that may be, we think few persons will assert that simple steel girder or trough-deck spans over city streets have a pleasing or attractive appearance when considered from the point of view of the picturesque. Where the span is long enough to require a truss it is usually recognized that little or nothing can be done beyond providing suitable design in the piers, abutments and wing walls. But by some attention to details the engineer may avoid unnecessary harshness or ugliness in the appearance of the truss structure. Of course, mere ornamentation or the application of incongruous architectural accessories is bad in principle and in effect, but on the other hand, there certainly are possibilities for softening the bald outlines and securing a structure which at least will not be an eyesore or a source of offence.

Girder spans and trough spans (the latter having only shallow side girders to retain filling and ballast) are prominent in the Chicago track elevation work. In a few cases such spans (as well as the deck spans of elevated railways crossing the boulevards) have been given a less bare and harsh appearance by the use of curved knee braces or shallow spandrels to give a somewhat arched appearance to the rectangular openings, or by means of metal moldings and ornamental railings to give some relief to the bare top line of the span. In certain cases, also, the use of concrete (or concrete encased) columns gives a better appearance than the ordinary bare steel columns; and where the spans are carried by abutments, some architectural or artistic treatment can usually be introduced at slight expense.

A method which has been used to some extent and with a varying degree of success, is to mask the steel structure with concrete portals. This may be objected to as forming simply a sham structure, and being, therefore, inartistic in itself, but the discussion of this side of the question of æsthetics we leave to others. A notable example of this class of work is a railway bridge over one of the driveways of Forest Park at St. Louis, where the single 70-ft. girder span is masked on each side by a concrete facia-girder surmounted by an ornamental balustrade and flanked by curved wing-walls of graceful design. This was illustrated in *Engineering News* of Nov. 17, 1904, and it is evident that the appearance is much more pleasing and more appropriate to the surroundings than the steel girder span.

Elsewhere in this issue we describe a recent case of a similar character, in which, however, the details of the treatment are very different. A railway is carried over an avenue or boulevard by a bridge 135 ft. between abutments, with four 28-ft. roadway spans and two short sidewalk spans. The headway is only 13½ ft., in order to secure a minimum elevation of the tracks and depression of the street. The general feature of the design was to encase the faces of the bridges and the end columns of the intermediate supports with concrete, so as to represent concrete girders and parapet walls, supported on concrete columns. The general effect is good, at least from some distance, but in matters of detail and finish the work leaves very much to be desired, as is explained elsewhere. The results indicate the difficulty of securing a satisfactory and pleasing appearance with concrete surfaces, especially where the concrete has a smooth skin-coat of cement. It is quite true that it is possible to give a good appearance to concrete, but it is equally true that this is not an easy matter and requires skillful workmanship and careful supervision

An unusual feature is the use of color to relieve the appearance of the large flat concrete surfaces, this relief being provided by colored tile inserts. The result appears better in the photographs than in the actual work. In fact, it is not easy to see why the surface was left flat, and it is probable that a much more pleasing effect could have been obtained by introducing paneling or molding to break up the large extent of flat surfaces by outline and shadow rather than by color. This view is substantiated by a comparison of the structure in question with some others crossing narrower thoroughfares on the same track elevation work and on the same railway. Here the face of the girder or parapet is paneled and has a simple projecting coping, while the surface is rough instead of having a smooth skin of cement, and the general appearance of the concrete is much more satisfactory.

One other point which may be touched upon in regard to track-elevation bridges is the relative merit of steel and concrete for these structures, from the point of view of appearance. Structures of both kinds are numerous in Chicago, and we are inclined to think that in this respect the concrete structure has an advantage. The paneled surface of the girders, the simple (but easily obtained) decorative treatment, and the massive columns produce an effect which cannot be arrived at in steel girders and columns. Further, in walking through the subway, the columns and the arches or curved struts connecting them (longitudinally with the street), give a colonnade effect to the interior which certainly is more pleasing than the sharp lines and angles of steel columns, girders, troughs and knee-braces.

In the case of steel bridges, the question of color may be considered in regard to the appearance. A dull brown or red is very common, and has a heavy and unsightly effect by making the bridge and its bare outlines unduly prominent in the view. There is no good reason why a more pleasing color should not be used for the finishing coats. In fact, some roads use a light greyish-buff color, which softens the appearance of the structure by rendering it less conspicuous. The Chicago elevated railways are great offenders in respect to the color of their structures in the public streets, using dark and dingy colors, because these will not show dirt and will require repainting only at long intervals. The worst case is the elevated loop structure, in the center of the downtown district; this has been painted black and is thus a very conspicuous and ugly obstruction, its color adding to the gloominess of the streets which it occupies. At one time the city required the use of light colors for these structures, and the improvement in the appearance of the streets at that time was marked; but either the paint or the painting was defective, as the paint very soon became streaky and patched, although this is not the case with the railway bridges noted above. Of course, the dark colors are economical from the point of view of the company, but certainly they are inartistic and unattractive, and they serve to accentuate any inherent ugliness or bareness in design of the structure.

One last point which we may mention in regard to bridges over streets and thoroughfares is the treatment of the surroundings. Both the municipal authorities and the railway officials should see that these are at least trim and neat. A bridge on which money has been spent for the sake of appearance may have its effect spoiled if the railway fill of the approach has untrimmed slopes of dirt and refuse instead of being dressed and turfed; the same ill effect may result from dirty and badly paved roadways, dilapidated sidewalks, dirty or rusty steel work, inartistic wing walls, and water dripping from the roof.

In some cities, municipal or other art commissions are giving these subjects attention, and trying to secure coöperation of the railways and the public authorities in securing bridges (both railway and highway), which will be of pleasing appearance. And we may add that such appearance is not incompatible with engineering design or economical construction.

Presidential Address to the Sixth Congress of the International Association for Testing Materials*

By Henry M. Howe†

The purpose of this association is to serve humanity by enabling it to distinguish the fit from the unfit among the materials with which the world's work is done, the materials for its buildings, its bridges, its ships, its railroads, its machinery, and its constructions in general. This is the function of the testing engineer; he stands between the public and the manufacturer who would supply that public, to test the fitness of those supplies, to measure accurately their degree of fitness, and to reject unsparingly the unfit. He is a guardian of the lives of those who travel by land or sea, and of those who live or work in buildings of important size. He is a protector of the material interests of the public, because in the last analysis all structures and all materials of which they are made are for the use and benefit of the public individually or collectively, and are paid for directly or indirectly by that public; and it is to the interest of that public that the fitness of those materials for their various purposes shall be known quantitatively to those who select them.

It is to make this work of the testing engineer more effective, to guard the lives and the interests of the public the better that this association exists. It is an open court in which the public sits in judgment on the various methods of testing. Of that public certain parts are here represented directly by their own engineers. This is true of the great railroads, the great shipbuilding and bridge builders, and the great engineering houses. Other parts of the public are represented indirectly by the middlemen or by the public engineers of tests.

The results of experience in all lands, in all climates, and under all conditions, and the points of view of all races, are here focussed in the most searching criticism of the various methods of testing, to the end that the buyer may gage their fitness with full knowledge, and thus may select intelligently those which give the fullest protection first to himself and ultimately to the public. If one method is unduly favorable to one manufacturer or to the manufacturers of one region or of one country by tending to gloss over the shortcomings of their product and to give undue prominence to its special merits, the public is here warned of the deceptiveness of that test by the evidence offered by the competing manufacturers.

However far distant may be the political "Parliament of man," which is "coming yet for a' that," the industrial parliament of man is already here. The buyer in each country may well say "My country is the world, my countrymen are all mankind," for wherever his abode he selects the fittest goods, quality and cost considered, without regard to their origin. While he is selecting his purchases, friendship, patriotism, national boundaries, empires, and continents cease to exist. Today's market place is the world, and our society is an essential part of that pentecostal market place, in which we enable all races to speak the common language of the methods of testing, that is of appraising the market place's competing goods.

An important phase of our work is the unification of the methods of testing throughout the world, to the end that the buyer may the more readily and the more justly weigh the relative merits of all competing materials of a given kind, from whatever country they may come. The day has passed when the buyer's ignorance, his inability to ascertain for himself the fitness of what is offered him, forced him to rely on the reputation and on the assurances of the manufacturer or exporter. Today he relies not on the untested assertions of the seller, however creditable, but on his own tests, or on tests made by his own agents. Purchase is no longer a matter of faith but one of knowledge. It is our mission and privilege to carry this substitution of knowledge for faith ever farther and farther.

Turning our attention now in a different direction and asking what our attitude ought to be toward attempts to replace or supplement our present methods of testing with new methods, we find that, though we have good reason to be dissatisfied with our present methods, yet we should be extremely cautious in the industrial adoption of new ones. Let us consider these two aspects briefly.

For every structure there are certain conditions which are more trying to it than all other conditions, certain conditions which it fulfills with the greatest difficulty. Its ability to meet these most trying conditions is the measure of its industrial and commercial fitness, usefulness, and hence value. The fact that I cannot lay my hand with certainty on these conditions does not affect the truth of this proposition. We may not know these conditions today, but they are intrinsically discoverable. The supreme danger to the chimney may be the gale. The supreme danger to the rail may be the unduly rapid impact of an ill-balanced driving wheel when the ground is frozen hard, and after the head of the rail itself has been brought from its initial ductility to the vitreous state by the peening of the wheels. The supreme danger to the hull plate may be the dynamic stress along the rivet holes in a collision. That which at last breaks down the well aligned factory shaft may be the inevitable slight variations of stress. In each case there are probably two or more supremely trying sets of conditions; but be they few or be they many, be they recognized or be they still undiscovered, there must in the nature of the case be such most trying conditions, the ability to endure which necessarily carries along with it the ability to endure all of the other conditions of use. It is to these most trying conditions that our tests should address themselves.

We assume reasonably that the ability to meet these most trying conditions will be measured most trustworthily by that test which reproduces these same conditions the most closely. For instance, in the many cases in which the most trying stresses are dynamic, it is reasonable to believe that a dynamic test is fitter than a static one. Or course we should not leap to the conclusion that any and every dynamic test is here fitter than any and every static test.

Here, then, is one direction in which most of our tests are very faulty. Their conditions are radically unlike the most trying ones of service. The light which they throw on the fitness of the object for its proposed service is most indirect. In that respect they are unfit tests.

An objection from a wholly different direction lies against most of our tests, the objection that, because they are tests to destruction, they cannot in their nature be applied directly to the object whose fitness they would gage, but instead they must be applied vicariously to small pieces assumed to represent those objects. We do not test the individual rails, boiler plates, shafts, bridge posts, or concrete columns on whose fitness the lives of our fellows hang, but small pieces cut from them, or for some other reason assumed to represent them. In certain rare cases we do indeed test, not such a small fragment, but a similar whole structure, a like beam or shaft or post. This is not as bad as measuring the endurance of your recruits by finding what forced march suffices to kill their brothers, but it is open to the same kind of objection, the objection that because it is destructive it must needs be vicarious.

But a great range and variety of indestructive tests suggest themselves, tests which leave no more effect on the piece tested than seeing, tasting, or smelling it would. The presence of cavities may be detected through the density; and that of plastic deformation through the potential. Microscopic examination is already well advanced. Magnetic testing has received much attention; and electrical disintegration is now pointed out as a means of test. The number of physical properties which offer themselves as possible means of testing is very great

*Delivered at New York City, Aug. 3, 1912. The address as here given is slightly condensed, but no strictly technical matter has been omitted.

†Acting President, International Association for Testing Materials; Professor of Metallurgy, Columbia University, New York City.

Here we note that Miers and Isaac determine the supersolubility curve of solutions by measuring their index of refraction of light, and that Hönigsberg and Coker study the lines of stress by the behavior of polarized light passed through transparent specimens. What do these things mean? They mean that light, a manifestation of energy, in crossing these bodies undergoes a change; and the nature of that change teaches us concerning properties in those crossed bodies little related to light; or in short the action of the body tested upon a form of energy passed through it or reflected from it may be made to disclose and to gage properties of that body but little related to that form of energy, and with no residual effect on the body itself.

But light is only one of a considerable number of forms of energy which seem open to such use. Sound, electricity, the divers kinds of radiations which only lately disclose themselves to our amazement, and the many yet undreamed ones awaiting discovery, these are forms of energy some of which may be harnessable to a like use.

Let us remember that later our analysis of these subtler manifestations of energy will be even fuller than our present analysis of the coarse radiations of sound. As today we know not only the pitch and volume, but the timbre, overtones, and harmonics of sound, so later shall we know corresponding characteristics and phenomena of these other kinds of radiation, so that we seem embarrassed by the riches of the variety of agencies from which the testing engineer of an age less crude than ours may choose.

Here lies the suggestion that we may learn the properties of the very rails and girders which we are to use, and later the properties of assembled structures themselves, such as boilers and bridge posts, and conceivably in the far, far future the assembled hull, by their action and re-action with some form of energy. Who shall say that the pitch or volume or timbre of sound emitted by a rail as the result of a given excitement may not be made to disclose pitilessly its hidden defects and to measure the fitness, not alone of the material of which it is composed, but of the rail as a whole structure? Or giving rein to our fancy we hear the inspector report, "This one-hundred story building indeed responds to G sharp, but its timbre has this abnormality and these harmonics are exaggerated."

These indestructive methods indeed have the defect of being indirect in one respect to weigh against their advantage of being direct in another; they are indirect in that they gage the properties actually needed in service by means of other properties; they are direct in that they may be applied to the very objects to be used, instead of vicariously to coupons or like objects to be destroyed in the test itself.

Their natural service seems to be to supplement the vicarious destructive tests. Thus the tester of the future may prove his material by the vicarious destructive tests of coupons, and prove his structures themselves by these indestructive tests.

* * * * * * *

Having thus considered the purposes of our society, let us turn to some tangible evidence of the progress made in accomplishing them since our last congress. First, four additional countries are represented in our Council—Japan, China, Canada and Brazil, by Messrs. Saito, Kwong, Hersey and di Paolo—bringing the number of countries represented on the Council up to 25. Second, our membership has increased from 2160 to 2680, or by 24%, and now represents 30 countries, and every continent. Adding the members for the present Congress year, our membership becomes about 3700. Third, in addition to the existing national societies closely affiliated with us in Germany, America, Italy, Austria, and Hungary, two new national societies have arisen in Russia; and in addition to the existing organization of our own members into a racial group in France and Belgium, a like national Swiss group has formed. I appeal to the members of Council from other countries to institute like works. Perhaps by this means better than by any other can they discharge that solemn trust which they accepted in entering the Council.

That we are recognized not as a private club for our own benefit and enlightenment but primarily and essentially as a benevolent institution, successfully aiming to benefit mankind, an institution to which our contributions of time and thought are such as no sordid motive could evoke, is shown by the generous and widespread response to our appeal for aid in this work, and by the action of many governments and important public bodies in appointing representatives on our commissions.

Here it may be mentioned that the volume of papers for this congress is about twice as large as that of any previous congress.

The Council contemplates ways of lessening the impediments to the efficiency of our international committees, due both to the language difficulties and to the usual need of carrying on their deliberations by correspondence instead of face to face.

* * * * * * *

The immediate purpose before the founders of our society was to perfect and unify the methods of testing; the ultimate purpose was to enable the public to get fit goods. But if I am to learn whether my purchase is fit by testing it, I must know not only how to test it, i.e., how to measure its properties, but also how much of each property it ought to have. Of what use is a process for testing axles by impact or tension unless I know quantitatively what tensile properties they ought to have and what impact they ought to endure? Of what use are methods of testing without reception specifications? One is the necessary complement of the other.

It so happens that, in building a society fitted for the immediate end of improving methods of testing, we have simultaneously fitted it for the indispensable supplement, specification making. In bringing together those competent to improve methods of test we have also brought together those most competent to draw specifications. We have "builded better than we knew." We have unconsciously made an organization fitted for filling both needs of the public, for telling it both what properties, quantitatively, its purchases need and also how to measure those properties.

* * * * * * *

I am not unmindful of the obstacles and pitfalls in the way of specification making. I understand the gravity of the commercial questions involved. I see that commercial interests may readily be antagonized into the position of resenting supposed interference. But let us look at obstacles as things primarily to be overcome and pitfalls as things primarily to be bridged, remembering that where there is a will there is a way; that the human beings with commercial interests on other continents do not differ in their innermost nature from the corresponding human beings on this continent; and that if it has proved possible to bring maker and user into harmonious and indeed enthusiastic coöperation here it ought to be possible there.

As men of your sagacity are ever anxious to profit by the experience of others, I commend most earnestly to your attention this opportunity which your American visit offers to profit by the special experience of the American Society for Testing Materials, which stands to you in a relation of filial affection and pride. The natural development of the American Society has happened to be in the direction of specification making. In our opinion, based on our now very considerable experience, this work has proved far more valuable, and of far greater profit to the public, than our simultaneous work of perfecting methods of measurement. Your visit here gives you an opportunity of judging the truth of this opinion, and, in case it shall seem to you true, the further opportunity of profiting by our experience in the methods to be followed and those to be avoided in this special work. Not less strongly do I commend to our American members this opportunity to learn from their foreign colleagues the work which they have

found most useful, and the means which they have found most effective.

In closing this address I ask the members of the committees who have labored so zealously and so wisely to organize and carry on this congress and its excursions to rise and receive the thanks which, on behalf of the Association, I give them from the bottom of my heart, and I ask their Chairmen, Messrs. Clark, Holmes, Humphrey, Hunt, Marburg, Moldenke and Schmitt, and the officers of the sub-committees, Messrs. Chapman, Dunning, Hamburger, Kinkead, Kunz, Miller, Moisseiff, Stoughton and Wight, to express our gratitude to the absent members of their committees. Our warmest thanks are due also to our indefatigable secretaries, General Secretary Reitler and Secretary Porter, for their most zealous and efficient labors.

Ladies and Gentlemen, I have sought to impress on you that we are among the guardians of mankind; that our services to humanity are of so high a nature as to stimulate us to seek earnestly how we may make them more effective and wider; that one means is to supplement and in time replace our present methods, which rightly viewed are but temporary expedients, with better ones; but that this replacement, much as it is needed, should be made with extreme caution. Classing the two kinds of testing into the vicarious tests to destruction on the one hand and on the other hand the indestructive tests applied directly to the objects which are to enter into service, I have pointed out that in the future these two classes of tests may well be used to supplement each other; that the vicarious tests should be made to reproduce as closely as possible the most trying conditions of service, and that the indestructive tests, with which we have hardly made even a beginning, hold out very wide possibilities of usefulness. I have urged on you our competence and our consequent duty to add specification making to our original plan, and thereby to increase very greatly our services to our brothers, and through our brothers to our Father. Here are tasks which may well fire our imagination, and stimulate us to an ardent consecration of our energies to the work of the International Association for Testing Materials.

A Municipal Opera House at San Francisco, Calif., is projected. The building will be erected from private funds raised, as we understand it, by the Musical Association of San Francisco. The estimated cost is $650,000. The building will stand on land owned by the city and would form a part of the new civic center, becoming the property of the city after its completion. The management of the building, it is stated, would be vested in 15 trustees, to be chosen by the city of San Francisco, the Musical Association, the University of California and Stanford University. It is stated that between $400,000 and $500,000 toward the cost of the building has already been pledged.

A New Special-Work Layout for Street-Railway Track

By F. M. Johnson*

It is becoming imperative to have uninterrupted traffic in street-railway operation, but in many cases, where long cars are used, time is wasted at curves at street intersections by a car waiting at the beginning of a curve while a car on the other track passes the curve, since the latter fouls the track of the former.

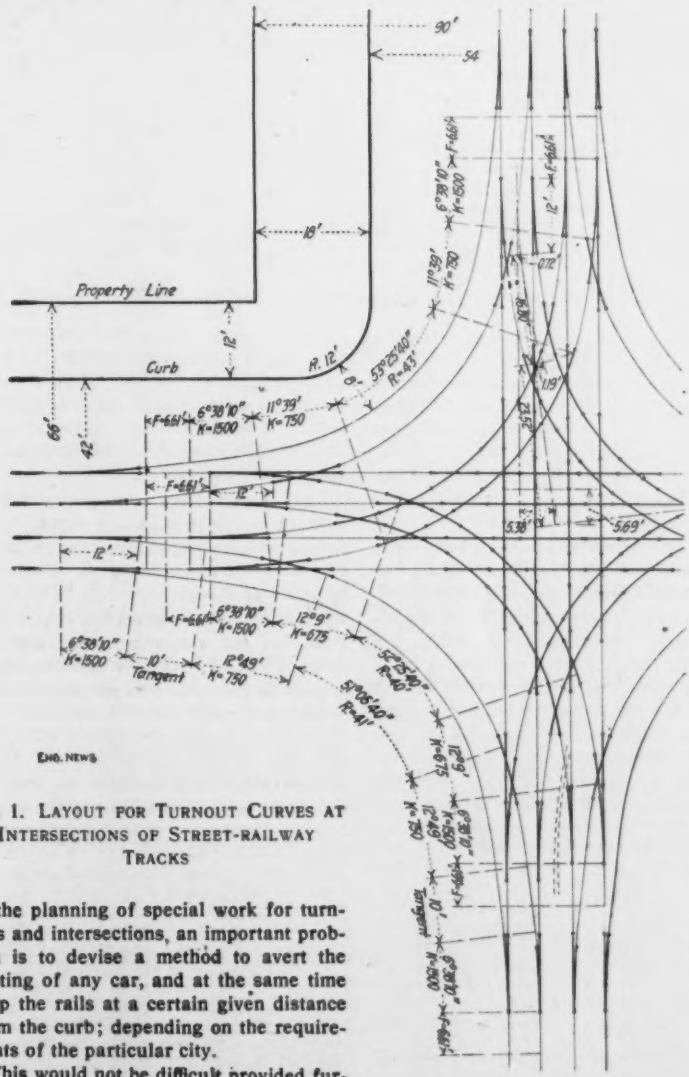

Fig. 1. Layout for Turnout Curves at Intersections of Street-Railway Tracks

In the planning of special work for turnouts and intersections, an important problem is to devise a method to avert the waiting of any car, and at the same time keep the rails at a certain given distance from the curb; depending on the requirements of the particular city.

This would not be difficult provided further desired requirements were not made. But the switch mate must not be crossed, and should be designed on a curve such that the minimum offset will make the mate about 10 ft. in length. The same design for switch and mate is to be used on both inside and outside tracks. The smallest radius is to be 40 ft., as that is the sharpest curve that a 6-ft. truck will ride. No tangent or compound curve is to be used on the outside track. Any spiral used should be at least 15 ft. in length. Ample provision must be made for the wheel tread at all points. The inside rail of the inside track must not be less than 8 ft. from the curb. These conditions are observed in the design shown in Fig. 1, which provides for uninterrupted traffic.†

The design of the outside track is the original feature of this layout. No tangent is introduced, but the same amount of space is made available as though the tangent were used. The car used was 49 ft. 3 in. long, 8 ft. 6 in. wide over sills, and 24 ft. 3 in. between truck centers; it had a drop platform, end entrance and round-cornered vestibule.

The first investigation was to determine the spiral to use. Several spirals were

*Designer, City Engineers' Office, Seattle, Wash.

†The curve and switch arrangement used in the reconstruction of the Chicago street railways was shown in our issue of Nov. 3, 1910, together with the design of switch used in that work.—Editor.

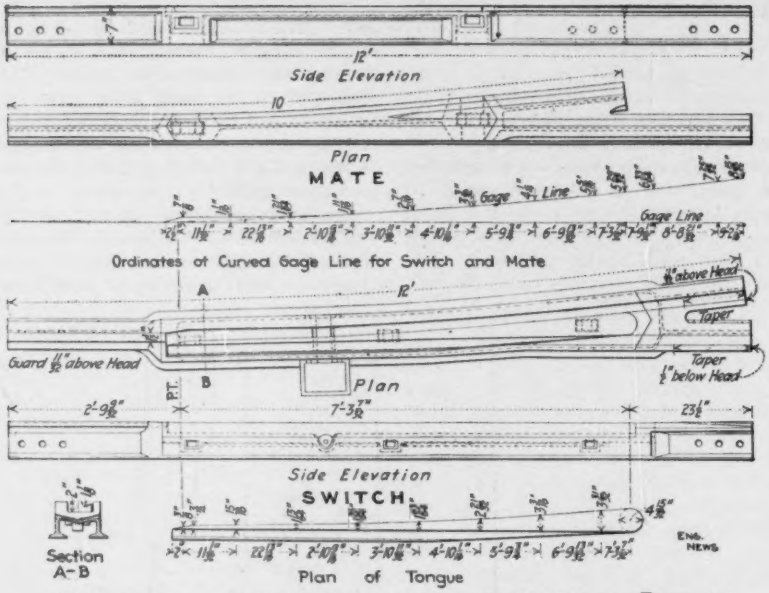

FIG. 2. SWITCH AND MATE CONSTRUCTION FOR STREET-RAILWAY TURNOUTS

tried, among them being the Crandall, Talbot, Searles and Pennsylvania; the Talbot was selected on account of being a true spiral, and the simplicity of computation. The switch was designed on a parabola, and so located that at a distance of 18.64 ft. from the P.C. of the switch spiral, a tangent to the spiral was tangent to the parabola.

Having determined upon the switch and mate, and the coördinates of same, the problem is to select curves that will fulfill the above requirements. On the inside track the radius is variable, the length of the tangent is variable, and the spiral is variable; that is, a variable "K" (see plan) for any given radius, making three variables which could be affected into an endless number of combinations. The "K" was assumed to vary from 500 to 2000, the length of tangent from 15 to 25 ft., and the radius from 40 to 55 ft. The inside curve was designed with 10 ft. of tangent at the end of each switch spiral, so as to throw the trucks away from the outside track. Several trials were made to eliminate the tangent, but they were unsuccessful.

The outside track was first designed with the switch spiral and a simple curve, but no combination of the above variables on the inside track would allow the cars to pass and at the same time fulfill all of the requirements. About twenty combinations of the variables were computed and plotted. Then the outside track was designed with the switch spiral, a second spiral and a simple curve. In this curve the "K" for the spiral was variable, and the radius was variable. These two variables, together with the three of the inside track, made five variables from which to make a location. The computations were pursued through each variable by methods of interpolation, increase and decrease. About fifty combinations were computed and plotted, that shown in the diagram, Fig. 1, being the best solution obtained.

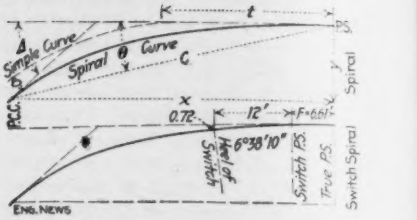

FIG. 3. DIAGRAM OF SPIRALS FOR STREET-RAILWAY TURNOUT CURVES

The radius and the spiral of the two outside curves differ, so that three rails will not intersect in one point. This gives support for the wheel tread at all points. The smallest dimension of the crown at this three-curve crossing was 2⅜ in. This layout gives 7 in. clearance between cars at the worst position, and fulfills all of the desired requirements.

The switch construction is shown in Fig. 2, while Fig. 3 and the accompanying table show the details of the spirals.

TABLE FOR SPIRALS OF STREET RAILWAY TURNOUT CURVES AT INTERSECTIONS SEATTLE, WASH.

Length	Radius	Δ	8	θ	y	x	t
K = 1500							
5	300	0°29′	0°10′	....	0.01	5	2.50
10	150	1°35′	0°38′	....	0.11	10	5.00
12	125	2°45′	0°55′	....	0.19	12	6.00
15	100	4°18′	1°26′	....	0.38	14.99	7.50
15.79	95	4°46′	1°35′	....	0.43	15.78	7.89
16.67	90	5°19′	1°46′	....	0.51	16.66	8.33
17.65	85	5°58′	1°59′	....	0.61	17.63	8.82
18.64	....	6°38′10″	....	....	0.72	18.62	....
18.75	80	6°43′	2°14′	....	0.73	18.72	9.37
20	75	7°38′	2°33′	0.22	0.89	19.97	10.00
21.43	70	8°46′	2°55′	0.27	1.09	21.38	10.70
23.08	65	10°10′	3°23′	0.34	1.36	23.01	11.53
25	60	11°56′	3°59′	0.43	1.74	24.89	12.48
27.27	55	14°13′	4°44′	0.56	2.24	27.10	13.60
30	50	17°11′	5°44′	0.75	2.98	29.73	14.96
33.33	45	21°13′	7°04′	1.02	4.07	32.88	16.60
35.29	42.5	23°47′	7°56′	1.20	4.88	34.70	17.55
37.50	40	26°51′	8°56′	1.45	5.77	36.68	18.75
40	37.5	30°34′	10°10′	1.76	6.96	38.86	19.81
42.86	35	35°05′	11°40′	2.16	8.51	41.25	21.16
K = 750							
Length	Radius	Δ	8	θ	y	x	t
5	150	0°57′	0°19′	....	0.03	5.00	2.50
10	75	3°49′	1°16′	....	0.22	9.99	5.00
15	50	8°54′	2°52′	0.19	0.75	14.97	7.50
16.67	45	10°37′	3°32′	0.26	1.03	16.61	8.32
18.29	41	12°49′	4°16′	0.34	1.36	18.20	9.13
18.75	40	13°24′	4°28′	0.36	1.46	18.65	9.35
20	37.5	15°17′	5°05′	0.44	1.75	19.86	9.98
21.43	35	17°32′	5°50′	0.57	2.27	21.23	10.68
K = 675							
16.88	40	12°09′	4°03′	0.30	1.19	16.80	8.42

Engineering in the Everglades

BY R. A. BOEHRINGER*

In view of the prevailing discussion of the Everglades of Florida, it might be interesting to the readers of ENGINEERING NEWS to know those general characteristics of the Everglades development which appeal to the life of the engineer. I was at one time resident engineer in charge of one of the main canals, known as the Miami Canal, which empties into the Miami River six miles above the city of Miami, located at the mouth of the river.

The resident engineer on this canal has his headquarters in Miami, but spends most of his time on the dredge at the head of the canal. Last October the dredge was 19 miles in the Everglades, and progressing at the rate of 1.5 miles per month. Daily communication by means of a launch was maintained between Miami and the dredge. Mail, ice and fresh food were brought daily, and the quality of board furnished on the dredge was first class. The engineer and inspector had a room on the dredge containing two berths, a table, bureau, chairs and a stationary washstand. All drinking water was distilled, and the health of the crew was good.

By the terms of the contract, the engineer is required to have one mile of the canal staked out ahead of the dredge and

*Assistant Engineer, Water Supply Commission of Pennsylvania, Telegraph Building, Harrisburg, Penn.

to furnish a profile showing the character of excavation down to subgrade. The center line and two side lines, 30 ft. on either side of the center, are staked out every 50 ft. Five "muck soundings" are taken at every 25-ft. station, and a copy of these cross-sections is furnished the contractor.

In general, the Everglades consist of a sea of saw grass and bushes growing out of the water with occasional open stretches sometimes covered with a brown scum; countless islands or "hummock lands," covered with a dense forest growth, break the otherwise flat surface of the Glades. The water is clear and varies from a few inches to 6 ft. in depth, while under the water is a black, soft muck of varying thickness overlying a coralline limestone.

Levels are run ahead of the dredge over the center line of the canal, after which the "muck soundings" are taken. This is done by sticking an iron rod down through the water and muck until the ring of the rod shows that the point is on the coralline limestone. The depths of water and muck are recorded in a note book and the elevation of the limestone is computed.

The dredge excavates the full required bottom width, the muck taking its own slope, and the excavated material is dropped over on the sides of the canal. Monthly estimates are made by taking soundings from a row boat in back of the dredge. These soundings are plotted up on the original cross-sections and the quantities of muck and rock excavated are computed.

The water of the Everglades is not stagnant and, although very sluggish, is constantly running toward the sea and is not unhealthful to drink. Mosquitoes are not numerous although, when the west winds prevail, they sometimes come in swarms. The nights are generally cool and pleasant with a brilliant array of stars overhead; occasionally, searchlights of steamers passing up and down the coast 25 miles from the dredge could be seen.

The work goes on night and day and, during the night, range lights are put in advance of the dredge. The first light is put about 200 ft. ahead of where the dredge is in the evening and the second light placed 100 ft. farther, thus using four lights, two on either side line.

In conclusion, it may be stated that the life of the resident engineer on one of the main canals of the Everglades is in general an easy one. Staking out the canal and taking the muck soundings in advance of the dredge is, however, a hard and difficult task physically, with moccasins and less harmful reptiles abounding, although none of the men have been bitten. Finally, the flat and changeless aspect of the Everglades and the monotonous sounds and life on the dredge are relieved by occasional trips to town.

A Powder Explosion at the plant of the Rand Powder Co., near Knoxville, Tenn., on Aug. 29, killed three and injured four of the employees. No explanation of the cause has been given.

A Rear Collision at the Vauxhall Station of the London & Southwestern Ry., in London, England, on Aug. 29, resulted in the death of two and the injury of forty persons. A crowded commuters' train from Aldershot was standing in the station, when a light passenger train, consisting of a locomotive and two coaches, crashed into the rear end of it. A defective switch is blamed for the accident.

The Explosion of Three Gas Tanks at the plant of the A. O. Smith Co., at Milwaukee, Wis., on Aug. 26, killed one employee and injured six others. The tanks were used for the storage of acetylene gas for welding purposes, and one explanation offered for the accident is that the gas was ignited by back firing from the welding machine. The pressure on the tanks at the time of the explosion was 40 lb. per sq.in.

A Derailment occurred, on Aug. 27, on the line of the Illinois Central R.R., near East St. Louis, Mo., and two employees were seriously injured. The New Orleans Flyer, a fast passenger and mail train, was traveling at about 35 miles an hour when the tender was derailed, due to a broken flange. Seeing the trouble immediately, the engineer threw open the throttle and broke the coupling between the tender and the first car, in an effort to keep the rest of the train from being wrecked. All the coaches were derailed and overturned, but none were telescoped. The steel cars are claimed to have prevented a great loss of life.

Forest Fires near Pasadena, Calif., are threatening to devastate the wooded portion of the Pasadena watershed. The fires started in Devil's Cañon, twenty miles northeast of Pasadena, and have made rapid progress. A force of over 150 men is busy, fighting the spread of the fires.

Derailment of an Excursion Train on the Cincinnati, Hamilton & Dayton R.R., near Antioch, Ill., on Aug. 25, was accompanied by the death of one and the injury of sixteen of the passengers. The wreck is attributed to a broken rail.

A Switching Engine Derailment on the Southern Ry., at Atlanta, Ga., on Aug. 23, resulted in the death of one man and the injury of three others, all employees of the railroad. A train of freight cars, coupled to the front of the engine, was being pulled into the yards at about 15 miles an hour, when the engine suddenly left the rails and pinioned under it two of the crew. The official investigation places the blame either on spreading rails or on a broken flange on the driving wheel of the engine.

Heavy Floods in Eastern England have caused much damage in the last two weeks. In Norfolk it is reported that 80 bridges have been washed away and numbers of small villages have been isolated, by the blocking of railroads and the washing out of roads. The city of Norwich has suffered the most and dispatches claim that a large part of it will have to be rebuilt. For a time the city was without lights and there was danger of a shortage of drinking water, but railway communication with London has been reopened and the floods are slowly subsiding.

A Rock Slide Interrupted Traffic on the main line of the Canadian Pacific Ry., at Roger's Pass, near Revelstoke, B. C., holding up six passenger trains on one side and seven on the other side of the buried portion of the track. The slide occurred on Aug. 26, and the block caused was only temporary.

Break in the Obispo Diversion, Panama—A portion of the Obispo Diversion was carried away by a slide of 300,000 cu.yd. on the east bank of the Culebra Cut, on the morning of Aug. 20, and the water in the diversion channel has since been flowing into the Cut. The break occurred about 150 yd. north of the concrete flume through which the diversion passes, near Station 1645, about three miles from the north end of the Cut. To stop the flooding of the Cut to the south, a temporary dike will be thrown across it opposite the toe of the slide, which extends about half way across the channel.

The portion of the Cut between the slide and Gamboa will be flooded during the time necessary for relocating the diversion to the east of the break, but the pumps at Gamboa will be worked to capacity to prevent, if possible, a rise of water beyond a depth of 10 ft. in the flooded channel.—(Canal Record, Aug. 21, 1912).

The Indictments against C. G. Elliott, former chief drainage engineer of the Department of Agriculture; A. D. Morehouse, his assistant; F. E. Singleton, chief accountant of the department, and R. E. Teele, formerly an accountant, charging them with false certification of accounts, were quashed on Aug. 30, 1912, by request of the government.

The Typhoid Outbreak at Ottawa, Ont., has been declared over by Dr. W. T. Shirreff, Medical Officer of Health of that city. Bacterial tests of the water-supply for the past five weeks, Dr. Shirreff is reported as having stated, show that the water may now safely be used without boiling. Dr. Shirreff adds that "every precaution has been taken to protect the all-steel intake pipe which is now being used exclusively."

New Orleans Adopted the Commission plan of city government on Aug. 28 by a vote of 23,900 for to 2127 against the plan. It is stated that the vote was light, only some half of the registered voters taking part in the election. The government of the city under the plan adopted will be entrusted to five commissioners, one of whom will be known as the mayor. The commissioners will hold office for five years. Candidates for the commissionerships will be selected at a primary held on Oct. 1, and the election will take place in November.

A Federal Highway Appropriation of $525,000 is now available under a law passed by the recently adjourned Congress. Of this amount $25,000 is to be devoted to the use of a joint Congressional Committee "to make inquiry into the subject of federal aid in the construction of post roads" and $500,000 is to be expended by the Secretary of Agriculture in coöperation with the Postmaster-General "in improving the condition of roads to be selected by them, over which rural delivery is or may hereafter be established." The appropriation is part of the Post Office Appropriation Bill.

The law provides that to avail themselves of the federal aid the states, or local subdivisions thereof, must appropriate twice as much as is received from the government. Further, the Cabinet officers concerned are directed to report within one year:

The number of miles of road improved, the cost of same, and such other information as they may have acquired, together with such recommendations as shall seem wise for providing a general plan of national aid for the improvement of post roads in coöperation with the states and counties, and to bring about, as near as possible, such coöperation among the various states as will insure uniform and equitable interstate and highway regulation, and for providing necessary funds for carrying out such plans of national aid, if it shall be deemed feasible to provide the same or any part thereof otherwise than by appropriation from the Treasury for that purpose.

According to press dispatches the administration of the fund is to be under the immedite supervision of the Office of Public Roads of the Department of Agriculture.

Lining Paxton Creek, Harrisburg, Penn., with reinforced concrete for a distance of 15,400 ft. is proposed, and bids for the work will be received until Sept. 9. James H. Fuertes, 140 Nassau St., New York City, is consulting engineer for the work, and D. E. Tracy is Secretary of the Board of Public Works of Harrisburg.

Plans for Sewage Treatment Works for Orange, East Orange and Montclair have been approved by the State Board of Health of New Jersey, subject to changes mentioned below. The original plans, made by Hering & Fuller, 170 Broadway, New York City, were outlined in our issue of May 9, 1912, p. 898. They called for Imhoff tanks, sprinkling or percolating filters, hypochlorite disinfection and final settling tanks, with a discharge of the effluent into Third River, a small tributary of the Passaic River. Strong opposition to the proposed works has been made by officials and citizens of Bloomfield and Belleville, on the ground of alleged prospective nuisance. A legislative bill, general in character, but really aimed against the location of the proposed works at the chosen site, was vetoed by Governor Wilson (see editorial comments in our issue of Apr. 18, 1912, p. 744). The opponents of the project then made protests to the State Board of Health, summoning consulting engineers to their aid. After considerable delay the board just named approved the plans of Hering & Gregory, with the promise that the effluent from the sprinkling filters be carried to the Passaic River through one or more outfall sewers—which in effect cuts out the hypochlorite treatment and final settling tanks but requires a mile or so of additional trunk sewer. The $80,000 to $90,000 of capital cost saved at the treatment works will go far toward paying for the sewer to the Passaic, besides which there will be a saving in operating expenses.

Personals

Mr. Paul McLoud, M. Am. Soc. C. E., has been appointed Chief Engineer of the New York State Department of Highways to fill the position recently held by Mr. Harry P. Willis, resigned.

Mr. J. A. M. Robinson, Jun. Am. Soc. M. E., has resigned as Engineer for the Brown Portable Elevator Co. to accept a position as Hydraulic Engineer for the American Well Works, Chicago, Ill.

Mr. John E. Chisholm, formerly Superintendent of Motive Power for the Chicago, Great Western R.R., has been appointed Chicago representative of the Industrial Supply & Equipment Co., with offices in the Old Colony Building.

Mr. J. G. Anderson, Assoc. M. Am. Soc. C. E., has resigned as Assistant Engineer for the Minneapolis & St. Louis R.R. at Minneapolis, Minn., to accept a position as Engineer for the Geo. J. Grant Construction Co., at St. Paul, Minn.

Mr. Francis F. Longley, Assoc. M. Am. Soc. C. E., who has been connected with engineering work at Watertown, N. Y., Washington, D. C., and Toronto, Ont., under Messrs. Hazen & Whipple, Consulting Civil Engineers, was admitted to partnership in that firm on Sept. 3.

Mr. George C. Cleveland has been appointed Chief Engineer of the Lake Shore & Michigan Southern Ry., succeeding Mr. Samuel Rockwell. The following promotions are also announced: Mr. Robert O. Rote, to be Assistant Chief Engineer, and Mr. Harry B. Reinsagen, to be Principal Assistant Engineer.

Mr. Samuel Rockwell, M. Am. Soc. C. E., Chief Engineer of the Lake Shore & Michigan Southern Ry., has been appointed Consulting Engineer, a position recently created for the purpose of investigation and consideration, by the company, of special engineering subjects. Mr. Rockwell's activities in railroad and municipal engineering work date back to 1864.

Mr. H. H. Quimby, M. Am. Soc. C. E., who resigned as Assistant Engineer of the bridge division of the Bureau of Surveys, Philadelphia, Penn., as noted in our issue of Feb. 29, 1912, has been reappointed to the same position by Mr. Morris L. Cooke, Director of Public Works of Philadelphia. Announcement is also made of the appointment of Messrs. W. P. Taylor and W. D. Uhler as Assistant Engineers in the Bureau of Surveys.

Obituary

Frank B. Lang, senior member of the firm of Lang, Lamoreaux & Lang, of Minneapolis, and one of the best known architects in the Northwest, died at his home on Aug. 28, at the age of 71.

George Halstead, Professor of Engineering in Manitoba University, died on Aug. 29, at his home in South Lancashire, England, following an attack of typhoid fever, contracted during his voyage across the Atlantic.

Joseph A. Powers, senior member of the firm of Powers & Mansfield, of Troy, N. Y., and a prominent civil engineer, died at his summer home, Genosta Lodge, Nantucket, Mass., on Sept. 1. Mr. Powers was a graduate of the Rensselaer Polytechnic Institute in the class of 1860, and was one of the most active members of the Institute alumni in every movement for its welfare. He was one of the pioneers in the development of the Hudson Valley Ry. and in the organization of the Northern Adirondack Power Co. Through his membership in the American Society of Civil Engineers, the Engineers' Club of New York, and the Rensselaer Society of Engineers, Mr. Powers had a wide circle of friends in the engineering profession. He is survived by his wife, two daughters, and two sons.

Constant Désiré Despradelle, Rotch Professor of Architectural Design at the Massachusetts Institute of Technology, and one of the leading architects of the United States, died at his home in Boston, on Sept. 2, after an illness of nearly a year. Professor Despradelle was born May 20, 1862, in Burgoyne, France, and graduated from the Ecole des Beaux Arts, Paris, in 1882. He served in various capacities under the French Government up to 1893, when he took up the duties of professor at the M. I. T. He was a member of the firm of Codman & Despradelle, Architects, and was prominent in the affairs of the American Institute of Architects, the Society of Beaux Arts Architects of America, and of l'Institute de France.

Engineering Societies

COMING MEETINGS

INTERNATIONAL CONGRESS FOR TESTING MATERIALS.
Sept. 2-7. Sixth congress at New York City. Secy. of organizing committee, H. F. J. Porter, 29 West 39th St., New York.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.
Sept. 4 at Washington.
Sept. 6-13 at New York City. Secy., Bernhard C. Hesse, 25 Broad St., New York.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 7-10. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Penn.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Sept. 10-13. Annual meeting, Buffalo, N. Y. Secy., L. C. Ryan, C. & N. W. Ry., Sterling, Ill.

NEW ENGLAND WATER WORKS ASSOCIATION.
Sept. 18-20. Annual convention at Washington, D. C. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 18-20. Annual meeting at Washington, D. C. Secy., Selskar M. Gunn, 755 Boylston St., Boston, Mass.

INTERNATIONAL CONGRESS ON HYGIENE AND DEMOGRAPHY.
Sept. 23-28. Fifteenth congress at Washington, D. C. Secy., Jonn S. Fulton, Senate Annex, Washington, D. C.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
Sept. 24-26. Annual convention at Buffalo, N. Y. Secy., R. D. Moldenke, Watchung, N. J.

NATIONAL IRRIGATION CONGRESS.
Sept. 30-Oct. 5. Annual meeting at Salt Lake City, Utah. Secy., Arthur Hooker, Salt Lake City.

AMERICAN ASSOCIATION FOR HIGHWAY IMPROVEMENTS.
Sept. 30-Oct. 5. Annual convention at Atlantic City, N. J. Secy., G. E. Pennybacker, Jr., Colorado Bldg., Washington, D. C.

International Mining Experiment Station Conference—This conference will be held at Pittsburgh, Penn., Sept. 13-21, and the following are among the topics to be discussed: Coal dust and gas explosions, instruments used in coal dust experiment galleries, methods of gas and coal analysis, methods of testing inflammability of coal dust, methods of testing hoisting ropes and safety devices, use of electrical appliances in gaseous mines, explosives, and breathing apparatus. Demonstrations will be given of various forms of mine explosions in connection with the other work of the conference.